The Welding Engineer

Edited by L. B. Mackenzie

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Reserve Material or Junk

There are two kinds of scrap piles: reserve material and junk. In the junk pile all discarded metal articles are dumped indiscriminately into heaps, without the slightest regard to possible salvage value. They are just so much scrap to be broken up and melted in a cupola or furnace. The reserve material pile is quite different. The various kinds of articles it contains are sorted with particular reference to salvage. Scrap pipe of given diameter and length is racked and stacked; scrap sheet metal is piled so that it can be easily cut into desired shapes; machinery or parts that can be reclaimed are placed under cover.

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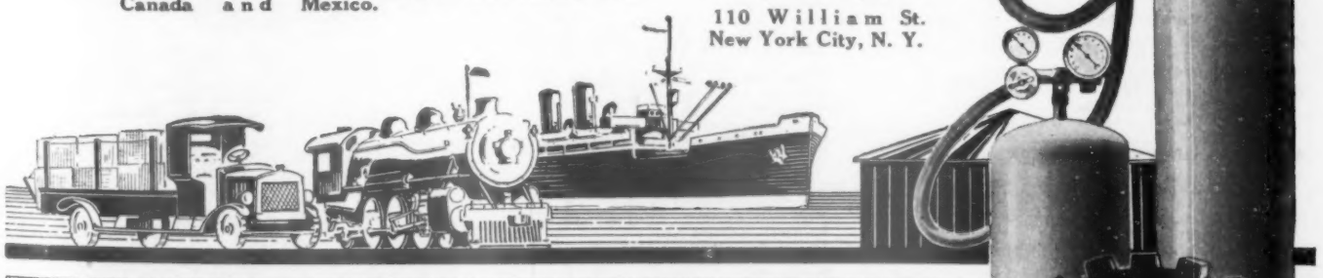

WELDING
PUROX
CUTTING

Buyers' Index

Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

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See "Torches"

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See "Torches"

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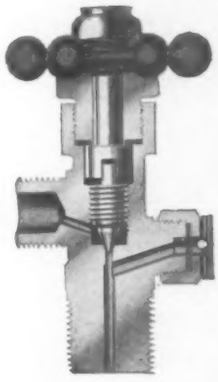


The Burdett Standard High Pressure Valve

This is a high grade single seat valve **at a popular price.** The swivel mounted tapered seat tip is made of Monel Metal.

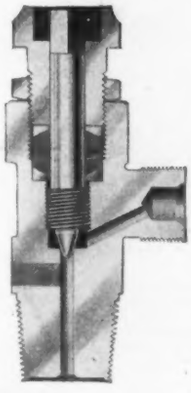
It does not twist nor wear so there are **no new seats to buy** and no "gas leakage" complaints from customers. The plug is connected **directly to the stem,** making a **stronger valve.**

No broken valve stems to replace.

No twisted valve tongs and spreading of split plugs.

No soft seats to replace.

For your Acetylene Cylinders



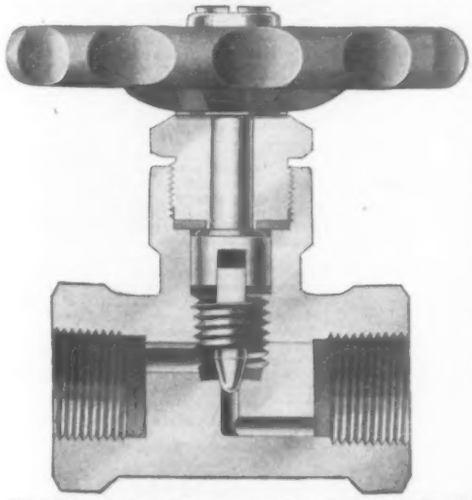
Burdett Acetylene Valve

It can't leak—The Monel Metal swivel seat is **gas-tight** when the valve is closed. The heavy asbestos packing **grows tighter** as the valve is opened.

It can't wear—The body is Tobin Bronze and the **one-piece** stem is Monel Metal, making a **practically indestructible** valve.

You can't go wrong if you buy
Burdett Valves for Acetylene Cylinders

For your Charging Stand Installations



The Burdett Master Valve

The ideal valve for **charging** stand installations or any place where you now have globe valves.

It is **lower in initial cost** than most globe valves—and there is **no repacking cost.**

It is **made gas-tight** and **stays gas-tight** eliminating costly gas leaks.

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Davis-Bournonville Co.
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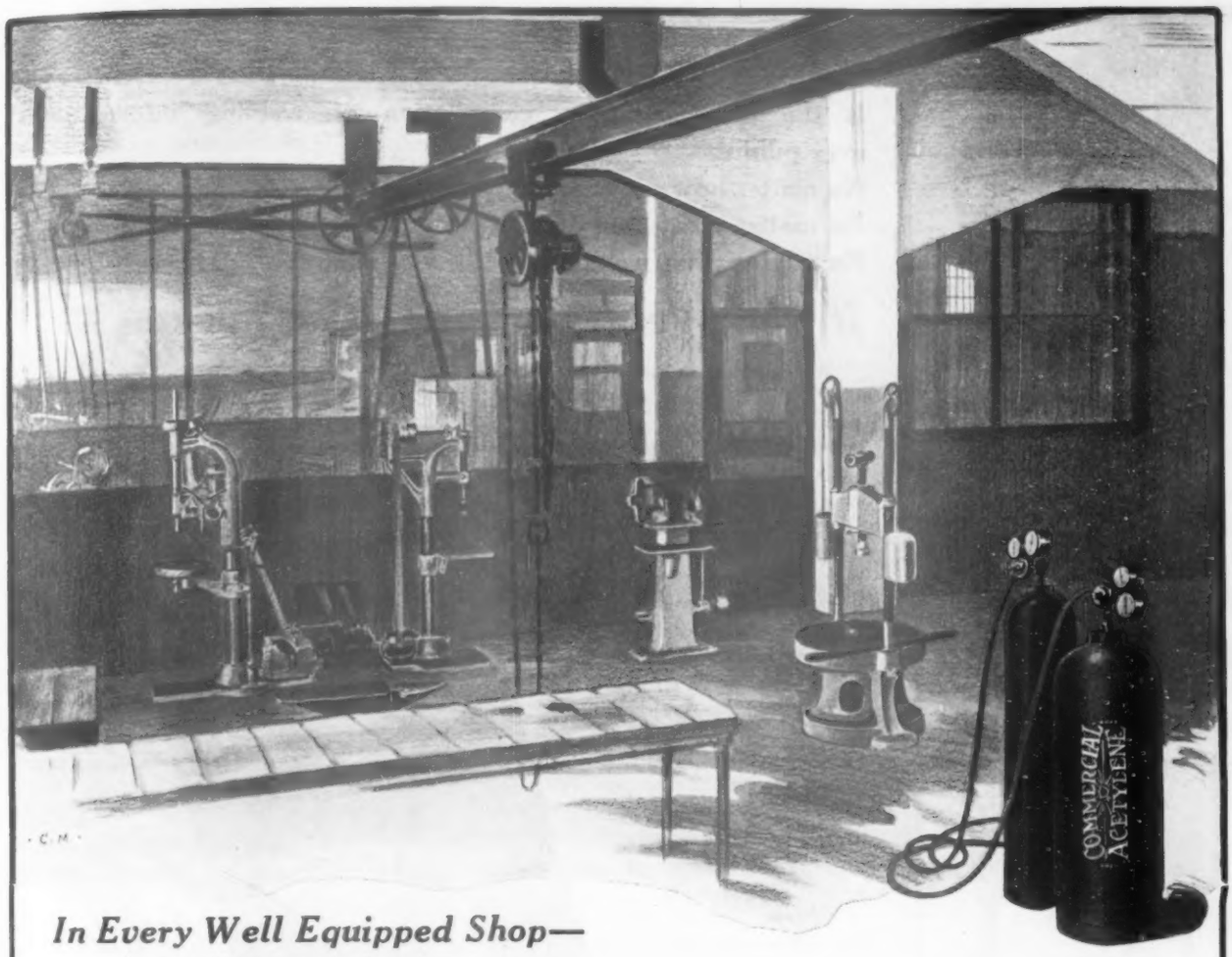

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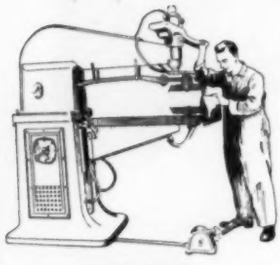

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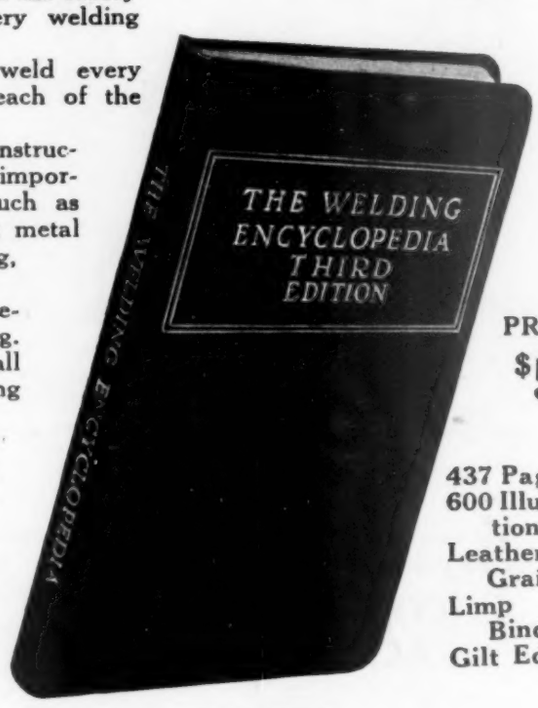

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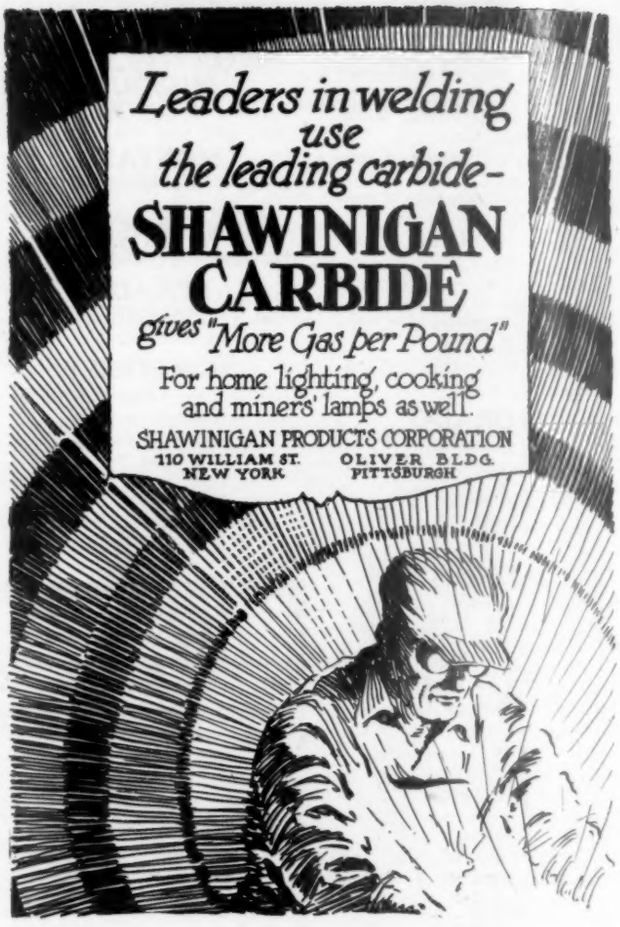
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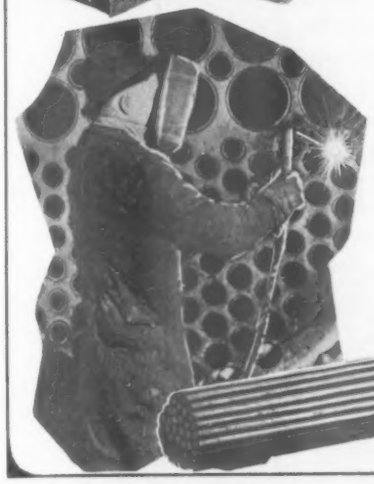

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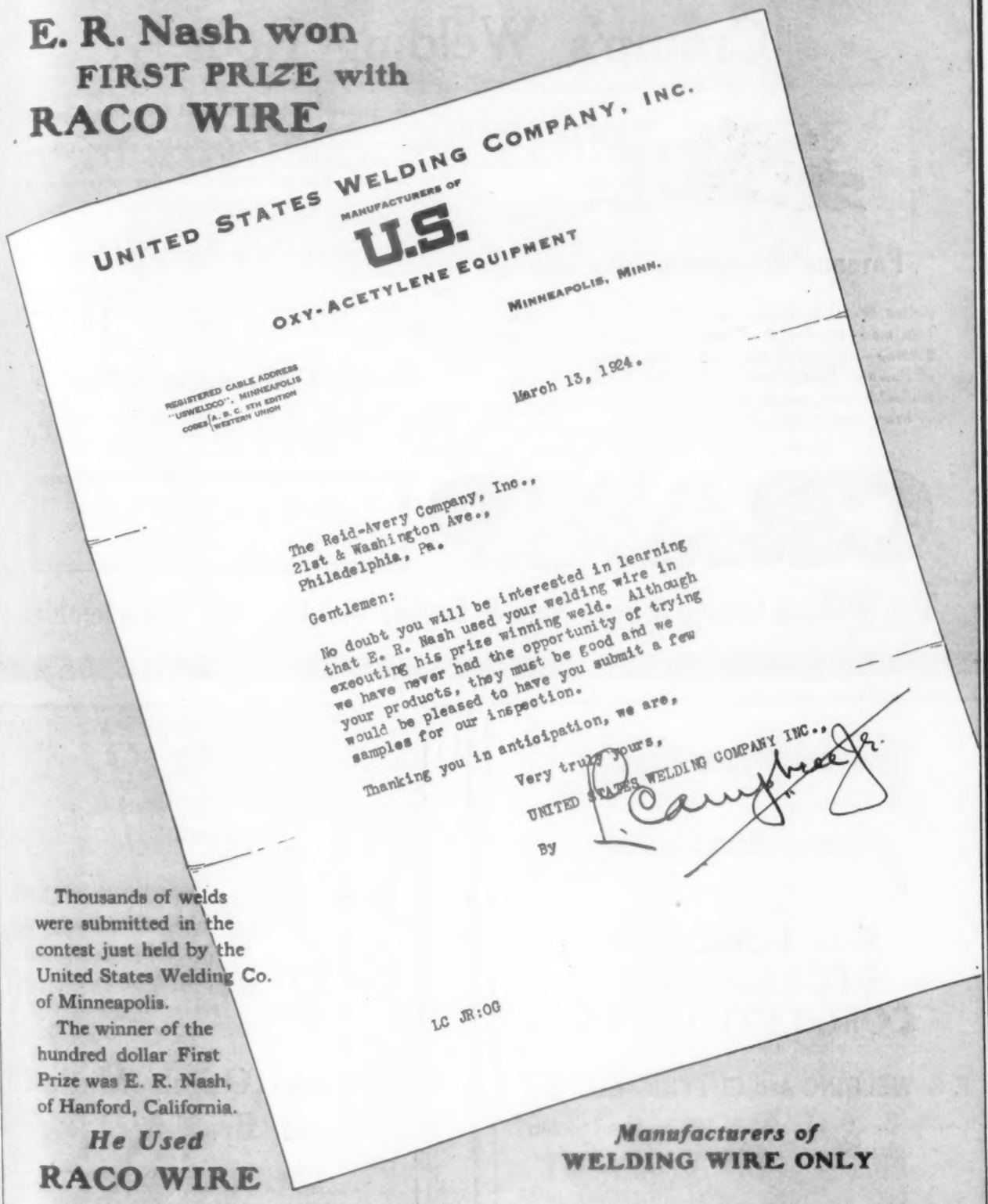

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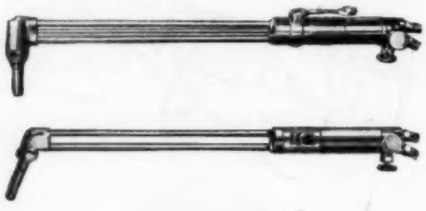

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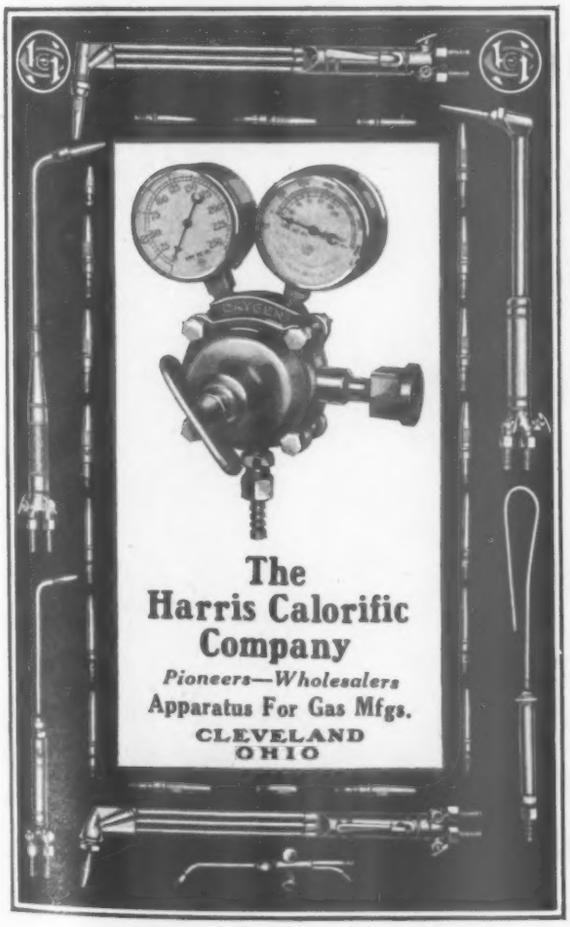

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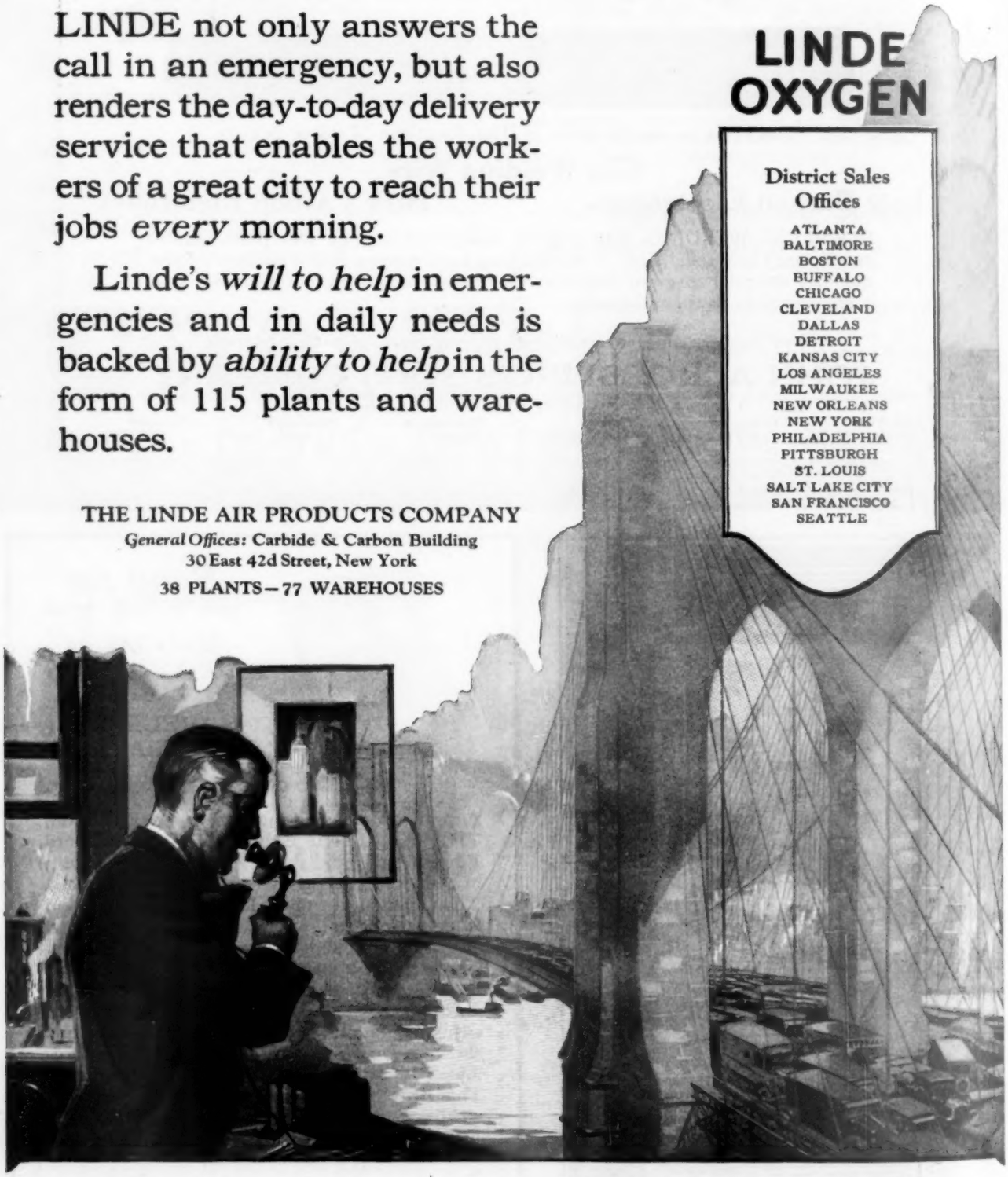


YOU CAN DEPEND ON THE LINDE COMPANY

ARC WELDED WELL CASINGS

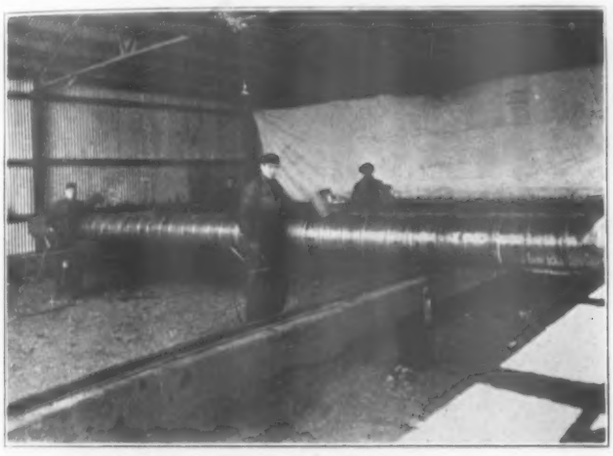
How the Work is Routed Through the Shop—Efficiency of Welded Casings — Time an Important Factor

By "El Soldando"

THE story of arc welding and how it is applied to the manufacture of oil-well casings by one of the leading manufacturers of oil field supplies in southern California is not a tale of remarkable tests, nor one of huge or intricate repairs. It is merely a story of efficiency in the handling of the large sections and the simplicity and economical production accomplished by arc welding in this field of work.

The casing discussed in this article is 13 in. in diameter and made of No. 10 gauge iron. It is two ply and built in 30-ft. sections, each section consisting of 10 3-ft. joints.

The inner ply joints are commonly called "insides" and the

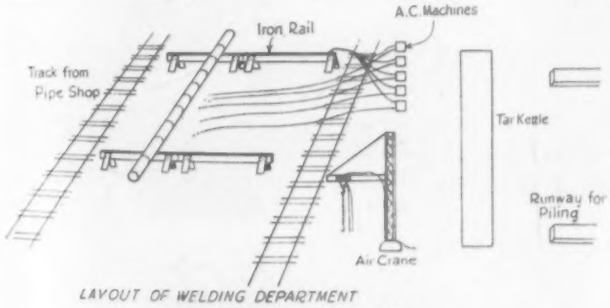


Welding Oil Well Casings is Carried On In a Special Shop.

outer ply joints are known as "outsides." The seams of both outside and inside joints are lapped and riveted, but due to the fact that they must stand a pressure of 550 lbs. per sq. in., the rivets have not been at all dependable.

To insure a stronger casing, arc welding was brought into use and as it naturally strengthened the casing to a great extent, it is rather interesting to note at what a small labor cost this was accomplished.

The "inside" joints upon being riveted are placed seams down upon a table, where two welders working from opposite sides of the table make five 2½-in. welds on each inner seam. On No. 10 gauge iron, care must be taken so as not to "burn" through, because the outside joints have to be rammed over the inner



Floor Plan of Welding Shop.

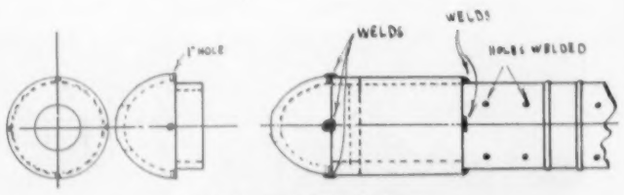
joints in the next operation.

Upon completing the welds, the joints are rolled from the table. Two welders are assigned to this table and in an eight-hour day the average two-man output is 720 ft. of casing, or 250 ft. of actual welding.

When the section is completed it is placed upon a truck and rolled into the welding room where it is rolled onto two tracks. These tracks are 75 ft. long and can accommodate 2,000 ft. of casing. The welding room is divided into compartments by a huge canvas screen suspended from the roof.

After a section has been completely welded, it is rolled onto another truck and upon being rolled out of the welding room, it is picked up by a crane and slipped into a large vat of hot tar. It is then piled ready for shipment.

In each 3-ft. outside joint, there are punched 12 ¾-in. holes.



Details of Welded Casings.

This is a total of 120 holes in a section. These holes, when welded, join the inner and outer casings. As to their strength, we can but use our imagination. To our knowledge, none has ever been tested to destruction.

As with the inside seam, there are five 2½-in. lap welds made to each 3-ft. of the outside seam.

With 120 ¾-in. holes and 21 ft. of lap welding to each 30-ft. section, it might seem that it was a costly form of production. However, we offer a few figures on this point, using alternating current machines, 170 amperes and a 3/16-in. coated electrode, one welder in an eight-hour day can weld four sections, or 120 ft. of 13-in. casing. This is a total of 480 holes a day.

This, when said quickly, sounds almost impossible, but when one considers that it is No. 10 gauge iron and, that there is no pulling or hauling of cables, the tracks are arranged so that the casing is in a convenient position, and does not necessitate any crawling around upon the part of the welder, it is then clear that waste has been cut to a minimum. It is, of course, a lot of welding, but not impossible, as it may seem at first.

On the lap welds of the outer seam, a welder can produce 480 ft. of casing in an eight-hour day. This is 43 ft. more than is done on the inside seams. This difference is due to the delay in the loading and unloading of the table.

There is then, to each 30-ft. section, a total of welds as follows:

Inside seams—10 ft. 6 in.	40 min.
Outside seams—10 ft. 6 in.	½ hr.
Holes, ¾ in.—120 ft.	2 hrs.
Total	3 hrs., 10 min.

Or an actual labor cost (first-class welder) of nine cents per foot of casing

When one figures the number of feet that the average well is drilled, there is no doubt that the cost of welded casing must exceed that of merely riveted casing.

However, in the old fields, where time is often a very important factor, the mere difference of so many cents per foot is not to be considered in the quest for a casing that can be relied upon for strength.

To every string (about 700 to 1,000 ft.) of casing there is a

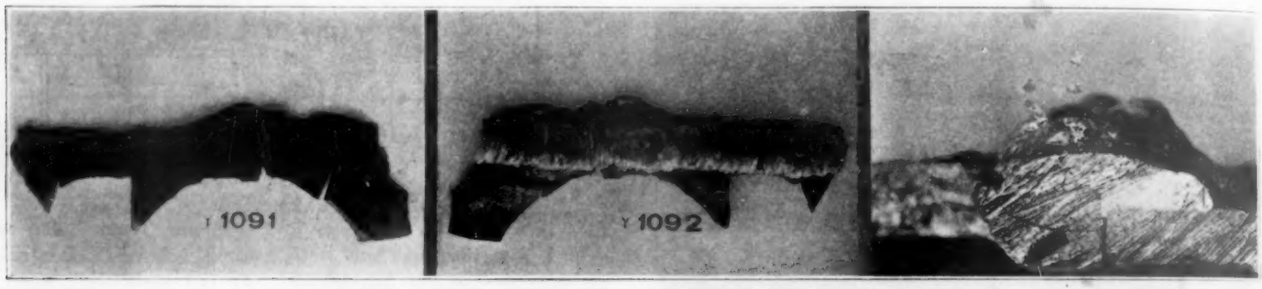
(Continued on page 28)

BRAZING PIPE JOINTS

Bronze Collar Applied to Cast Iron Pipe Promises to Become Important Development in Pipe Welding

ALTHOUGH more expensive than steel pipe on account of its greater thickness, cast iron pipe is generally accepted by gas companies as more desirable for gas mains for the reason that it has a greater resistance to corrosion. There are a number of operating conditions under which it is desirable to use steel pipe in spite of its short life, but the developments of a new method of joining pipe sections promises to increase the popularity of the cast pipe, and this is further encouraged by the disposition on the part of manufacturers of cast iron pipe to raise the quality of their product.

Engineers of the Linde Air Products Company have been working for some time on a method of making brazed joints which promise to be more satisfactory than welded joints, and altogether the most economical type of joint available for this work. The brazed joint has not yet been widely enough applied, nor long enough in service to be considered standard practice, but its response to tests and the satisfaction expressed by the few users who have adopted it, indicate that this class of work will not long be referred to as being in the experimental stage.



Test Specimens of New Type of Brazed Cast Iron Pipe Joints.

In effect the oxy-acetylene brazed joint in cast iron pipe is a bronze collar or band, a little more than an inch wide and about 3/16 in. thick, applied to plain ends of iron pipe, simply butted together. The photograph at the right of Figure 1 shows a section of a typical joint. It will be seen that no attempt has been made here to secure penetration. In fact on account of the necessity for making the slight expansion and contraction allowance, it is not desirable that penetration should be secured.

The close bond is desired between the bronze collar and the top surface of the ends of the pipe. It is well known that bronze which has been properly deposited on cast iron cannot be pulled away without pulling some of the iron along with it. So if this joint is well made, there is sufficient strength at the points indicated. As far as bending of the pipe is concerned, resistance to such bending is offered by the thickness of the bronze collar.

One of the advantages of this type of joint is the ease of application. It is not difficult to learn how to fuse the bronze properly and make it stick to the iron. The operator does not have to worry about penetration, and his work is all up on top where it is easy to handle. The process is also economical in time and gas consumption because this sort of joint requires less heat than the making of a regular cast iron weld. Its economy offsets the greater cost of the bronze welding rod as against the cast iron welding rod. A number of interesting tests have been conducted to determine the strength of the joint obtained in this manner, and all of them have thoroughly demonstrated that the lines welded in this manner would withstand shocks greatly in excess of those ordinarily experienced in service and in handling.

Another important advantage from the point of view from the gas company is the ease of applying this process to other types of joints which are needed in the lines. Two of the photographs in Figure 2 will serve to illustrate the possibilities in this direction. Joints of this character have been tested and proved satisfactory, so the brazing process is also recommended for the construction and application of fittings. The cast iron pipe manufacturers raise no objection to the adoption of fittings fabricated in this way, because there is not so much profit in the manufacture of cast fittings as in the manufacture of plain pipe, and the successful application of brazing to construction of cast iron gas mains promises to result in a more extensive use of the better grade of cast iron pipe.

Some of the photographs reproduced here illustrate very well the characteristics of the bronze welded joint described above. In Figure 1 the first two photographs show both sides of one of these joints which has been flattened with a hammer. The cast iron has cracked and broken in a number of places while the bronze collar has not cracked nor has it been separated from the iron.

How Brazing is Used to Make Either Butt Joints or Specials.

Figure 3 illustrates a piece of pipe which has been joined by this process, a piece broken out of it with a hammer blow, then a small section cut out through the joint.

Figure 3 is a photograph of one of the bending tests which has been applied to this type of joint. Three 12-ft. sections were

joined, and as the weights applied to the joints were increased, the amount of deflection was measured. A weight of 796 lbs. on the joint at the left and 818 on the joint at the right produced a deflection of 2⅛ in. at the left joint, 2¼ in. at the right-hand joint and 2½ in. in the center. Increasing the load at the left to 998 lbs. and the load at the right to 997 lbs. caused a deflection of 2⅞ in. at each joint and 3¼ in. in the center. Failure occurred when a load of 1,398 lbs. was applied at the left and 1,367 lbs. at the right.

How Brazed Joints Were Tested.

Figure 8 is a photograph of one of the broken joints. These were examined carefully and indicated that the bronze joint displayed all of the characteristics expected of it.

The development of this type of joint indicates the progressiveness which is characteristic of the welding industry, whose engineers refused to be misled into thinking that the process has reached its highest stage of development and application, and are constantly experimenting with improved methods and procedure of widening the field of application for the process and usefulness of the apparatus and materials produced for the industry.

One of The Broken Joints.

A short time ago when the Illinois Gas Association was holding its meeting at Hotel Sherman in Chicago, engineers of the Linde Air Products Company had, on display in the hotel, a number of samples of oxy-acetylene brazed cast iron pipe, some of which had been broken to show the nature of the joint secured by this process, and also a lantern slide display illustrating the series of tests referred to above. This created considerable interest on the part of the local and visiting members of the gas industry.

Section of Pipe Through Brazed Joint.

OXYGEN BUSINESS GOOD IN TULSA

Willard Foster, President of The Tulsa Oxygen Company, was in Chicago on March 27-28-29, attending an oil association convention at the Congress Hotel and attending to business having to do with the expansion of his company's production capacity.

It is reported that Mr. Foster plans to erect additional oxygen plants during the year and also one or more acetylene plants. He has secured the contract for oxygen and acetylene from the Frisco and other railways. Mr. Foster declined to confirm these reports but stated he was considering expansion and was not yet ready to announce where plants would be erected. His associates in the company are wealthy oil men whose companies are large consumers of oxygen and acetylene.

It is gratifying to note the rapid progress The Tulsa Oxygen Company has made in the short time they have been in business.

Mr. Foster is boosting Tulsa as the meeting place for the convention of the Gas Products Association next January, as they are building a twenty-two story hotel, which is almost completed, and which will be one of the best hotels in the South, and, by the way, it is all financed by Tulsa capital.

WE CANNOT FURNISH IRISH ROSES

Editor:

Kindly advise if you can furnish a copy of "My Wild Irish Rose From the County Mayo." If not please advise name of Publishing Co. that can furnish same.

Answer—We cannot give you the addresse of "The Wild Irish Rose." The last seen of him he was in attendance at the banquet given by the Gas Products Association, and we would suggest that you communicate with the Secretary of the Association, Mr. C. T. Price, 140 S. Dearborn St., Chicago, Ill.—Editor.

HEAVY JOBS DISCUSSED AT CHICAGO MEETING

At the April meeting of the American Welding Society, Chicago Station, W. L. Senbert, proprietor of the Chicago Welded Products Co., gave an illustrated talk on the various types of work which finds its way to the job shop. Several very heavy jobs were shown, which called forth some interesting discussion. M. A. Dantzler, of the Gas Tank Recharging Co., Milwaukee, read a paper on "Acetylene," which was followed by a lively discussion of points raised by the paper.

AHLDIN MOVES TO CHICAGO

David Ahldin, formerly chief engineer of the Commercial Acetylene Supply Company, New York, has recently become associated with Mr. Keith Dunham, Chicago. Mr. Dunham is now ready to furnish advice and engineering service for acetylene generating installations. Mr. Ahldin is well known in the industry through his long association with the commercial organization, and has served a term as president of the International Acetylene Association.

The Buckeye Oxygen Company recently placed in operation at Canton, Ohio, a new Oxygen Plant with monthly production capacity of two million cubic feet. The complete installation, which is of the Air Liquefaction Type, was made by the American Oxygen Machinery Corp., 50 Church Street, New York City.

ARC WELDING CAST IRON

How to Use the Monel Metal Electrode—Necessary to Keep Work Cool as Possible — Welds Properly Made Can be Machined

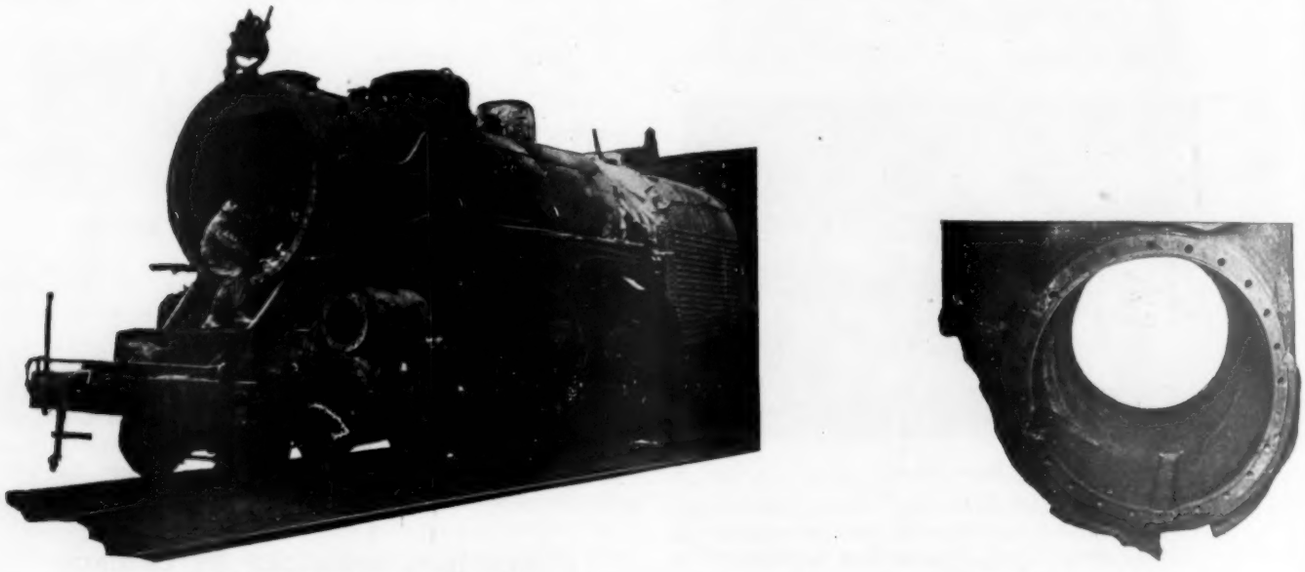
ONE of the difficulties which has confronted the arc welder in connection with the problem of making repairs on iron castings with the metallic arc is that in numerous cases it is desired to machine the casting after the weld has been made, and a machinable weld in cast iron has not been an easy accomplishment for the average operator. In cases where machining is not necessary, several efficient and satisfactory methods have been developed. The studding process for example has been very popular and is widely used. In this process the elctrode material has commonly been soft steel.

When a weld is made in cast iron with the metallic arc, using a steel electrode, it is found that on the cast iron side of the line of fusion, the cast iron which has been melted in order to accomplish fusion with the steel which has been added is chilled by the mass of cold metal of the piece, and becomes hard and brittle. On the steel side of the line of fusion, there is a marked increase of hardness in the steel due to the absorption of carbon in the cast iron. In fact, the first layer of steel has been changed from a mild steel to a rather high carbon steel through this process.

In order to overcome the difficulties in machining welded iron castings, it has been necessary to develop electrodes especially for this class of work. These electrodes are in effect special alloys. It has been found that Monel metal is an alloy admirably suited for this work if properly applied. In a recent issue of INCO, a publication issued by The International Nickel Company, Mr. T. E. Bransome describes the recommended practice, while calling attention to the fact that the use of Monel metal electrode is not a new idea since it has been marketed for some time by the Wilson Welder & Metals Company, as their Grade No. 12 welding wire.

Care is necessary in beginning the use of the Monel metal electrode, and therefore the method of procedure which is being widely used in both repair and production work is explained in detail. Because there have been so many over-optimistic claims advanced for special processes of all kinds, it is suggested that those interested in procuring consistently good results take pains to follow the instructions given closely, so that they can determine from the application of the rules exactly as laid down how to make their own welds consistently good.

It has already been pointed out that when cast iron is welded with a steel or iron electrode, the fusion is usually hard and non-machinable, and in operations where the use of a grinding wheel will not produce the desired surface, a change in procedure is necessary, and usually means the use of specially selected electrode material. The welding wire already mentioned is Monel metal treated with a special coating of flux which offers an envelope or sheath for the metal while it is passing through the arc, thereby tending to exclude the oxygen from the atmosphere. It is claimed that the use of this material with the metallic arc and the proper welding apparatus offers a surface to the machine tool, that is to all intents and purposes, identical with the parent metal. As a typical example of the successful results which can be obtained by using it as directed, the following letter is quoted:



This Cylinder was Welded with Monel Metal. **Fig. 1.**

"Over two years ago the locomotive shown above came into the shops of a large trunk line railroad with a cracked cylinder. While undergoing a general overhaul, this crack was welded with No. 12 Monel metal wire, .148-in. diameter. Approximately 75 lbs. of wire was used. Figure 1 illustrates the large cracks partially welded. After the weld was finished it was machined ⅛ in. below the surface with a boring bar, using a cutting tool as illustrated in Figure 2. The total cost of this welding repair was about $200."

As Monel metal flows differently from any other welding metal, an operator must accustom himself to its use and not expect to obtain perfect results with the first attempt. It cannot be deposited overhead satisfactorily, so as a general rule the work should be flat. In the hands of a skillful operator it may be deposited vertically if judgment and caution are exercised. It should always be deposited on a cold section of the casting and a bead not longer than two inches laid at one time. Immediately upon striking the arc, this bead should be carefully peened with a light ball peen hammer. This produces a forged effect in the welded metal and relieves it of the strain due to cooling. It also closes up what heat cracks might have developed.

When using this electrode to weld a casting in which there is

pressure or a vacuum after the Vee or opening has been padded with two layers of metal, all having been peened as above mentioned, the entire weld should be carefully and thoroughly calked either by hand or with a pneumatic tool.

In connection with the peening of every two-inch bead, calking should be continued after every second layer, and when the opening or the Vee is entirely filled in with Monel metal, the whole mass should again be calked and also gone over with a roughing tool. Particular care should be taken to deposit each and every two-inch bead on cold metal, so it is therefore necessary to either keep moving from one part of the casting to another, or to cease welding operations until the metal has thoroughly cooled down. Welding cast iron must necessarily proceed

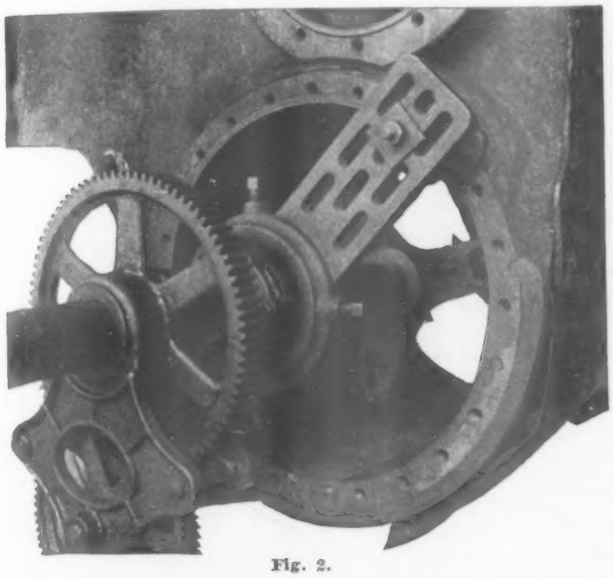


Fig. 2.

slowly and where the above suggestions have been conscientiously followed by the operator, satisfactory results will be obtained.

The Monel metal electrode for cast iron may be used with any type of electric welding machine, provided a temperature equivalent to the current recommended is maintained. Current at 175 amperes and a short arc is recommended for the 5/32-in. diameter, 100 to 130 amperes for ⅛-in. diameter, and 80 to 100 amperes for 3/32-in. diameter.

It is most essential that the welding machine used produces the above suggested amperage constantly. It may be necessary with some welding equipment to set the panel switches for a higher amperage than the above given in order to insure an average of those recommended.

Care which has been taken to find the exact details of procedure which give the best results illustrates an important fact regarding welding processes in general that is, good results are not dependent upon the material entirely nor upon the machines entirely, nor upon the operator entirely. The welder who claims to get fairly good results because he uses some special material very often has a special way of using that material which helps him considerably. Therefore in trying to duplicate the experiences of other operators, the welder must learn the little details of their method of operation, which is sometimes more difficult than obtaining simply a knowledge of what machines and materials they use. Successful operators often omit such details, not because they wish to keep them as trade secrets, but because through constant use they have become too commonplace to seem worthy of mention.

G-E FINDS SUGGESTION COMMITTEES HELPFUL

An index of the effectiveness of the system which rewards workers for suggestions is found in the recent compilation made by Suggestion Committees operating in plants of the General Electric Company.

Of the 8,078 suggestions reviewed by the various committees in the Works 1,752 were accepted. Awards ranging from $1 to $500 were paid to those whose suggestions were accepted, making a total of $22,988 paid out in cash awards during 1923.

Briefly, the operation of the suggestion committees is as follows: suggestions for improvements are focused through a small committee in each works. This committee investigates the suggestion, passes upon the merit of it, and makes the award to the man or woman who made the suggestion, or explains why the suggestion cannot be effectively adopted. In most cases the award can be made within a period of a few weeks after the suggestion is received; where it is necessary to put the suggestion into practice in order to determine its value, a longer time must elapse. The nature of the suggestions have a wide range from additional protective devices to new methods of working materials, and include new methods of following production, as well as improvements in plant publications.

NEW OXY-ACETYLENE PLANT ADDED TO SOUTHERN PACIFIC SHOPS AT SACRAMENTO, CAL.

A new oxy-acetylene plant has just been completed at the Sacramento, California shops of the Southern Pacific Company. These additions will greatly add to the facilities at the large shops and are in line with general policy of the Company toward keeping a step ahead in meeting transportation needs.

Acetylene gas is manufactured in the new plant and piped to all parts of the shop grounds, doing away with the portable generators or the cartage of tank gas to the job. In the acetylene generating house five 300-pound generators are installed. The oxygen is distributed from manifolds so that the man doing cutting or welding has only to carry his torch and hose around with him, coupling on to the outlets which are placed at convenient points. The oxygen is purchased in steel tanks into which it has been compressed at a pressure of about 2,000 pounds per square inch. These tanks are attached to the manifolds and the pressure reduced to 75 pounds per square inch for delivery into the pipe lines. On the acetylene line the pressure is 15 pounds per square inch.

SMITH-HEYLANDT CO. ORGANIZED AT MINNEAPOLIS

News has been received of the organization of the Smith-Heylandt Company with home offices at 2633 4th Street, Southeast Minneapolis, Minnesota.

The Smith-Heylandt Company is capitalized at $500,000.00 and has been recently organized to take over the patents, importation, sale and distribution of the Heylandt apparatus for the manufacture of gases by the liquefaction process. In addition to liquefaction apparatus, liquid oxygen breathing equipment will also be manufactured.

Mr. Elmer H. Smith, president of Smith's Inventions Incorporated and the Commercial Gas Company, heads the new organization as president. Mr. John R. R. Miles will be secretary. Mr. Herman G. Amling of Maywood, Illinois, the former representative of the Heylandt Company will co-operate with the new organization and thus give them the benefit of his several years of experience in the business.

Mr. Smith advises that a new and complete catalog is being prepared and will appear in the very near future. This catalog will explain and illustrate the full line of equipment that will be manufactured and imported.

The annual meeting of the American Welding Society will be held on April 22nd to 24th, in the Engineering Societies Building, 33 W. 39th St., New York. Some novel features are under consideration, including a smoker, at which a moving picture will be shown. The general program will also include a banquet and an inspection trip.

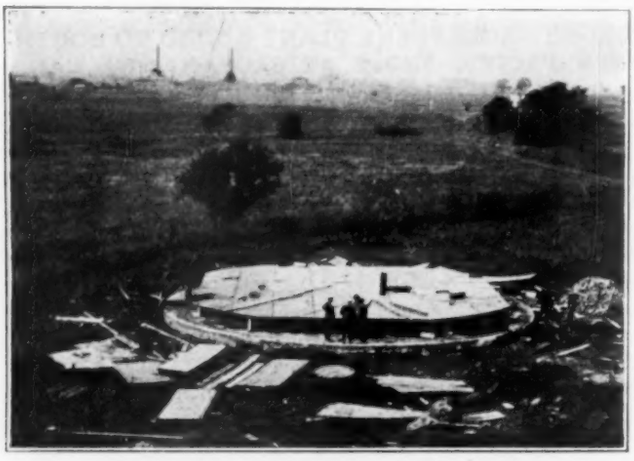
Oxy-Acetylene Welded Gas Holder*

Procedure Followed in the Construction of a Fifty Thousand Cubic Feet Capacity Tank

By G. O. Carter†

DURING the past year the various subsidiaries of the Union Carbide and Carbon Corporation have been doing some interesting work to advance the application of oxy-acetylene welding. Oxweld Acetylene Company started the work and with the cooperation of The Linde Air Products Company's Service Department welded two one-thousand barrel oil storage tanks for an oil pipe line company in Ohio. This work was completed in January of this year.

These tanks were 20 feet in diameter by 18 feet high and made of quarter-inch steel plates, with a light steel roof. It was necessary to "feel the way," so only a small welding crew was



View from Top of Partly Erected Chimney.

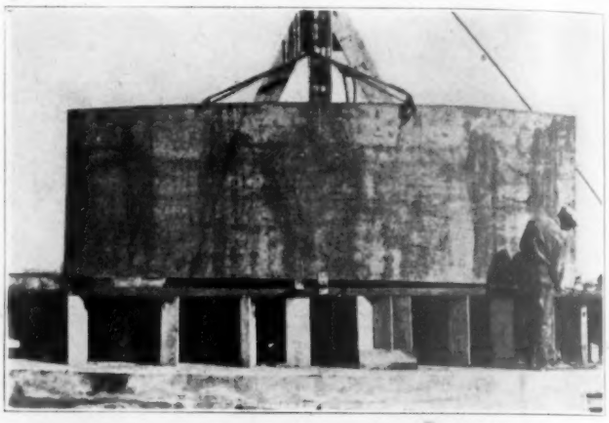
assigned for the work. The pipe line company's engineers properly commented on the length of time required to weld these tanks, as riveted tanks of that size can be built in a couple of weeks. There was also considerable trouble with the bottom plates buckling, and a little with the side sheets.

The completed tanks have given good service for almost a year now and will, of course, be watched for a long time to determine their durability and non-leakage qualities. Several things were learned from this job which were later incorporated into plans for somewhat similar work: that of building a gas holder for either an oxygen or acetylene plant.

Shortly following the completion of the oil storage tanks above mentioned, the Union Carbide Company decided to try oxy-acetylene welding for a very large rotary lime kiln and three lime coolers, to be built by The Reeves Brothers Company, and a coal dryer to be built by The McCann Engineering Company. The Linde service engineers cooperated with the builders and purchaser in this fabrication work, which was successfully completed, the equipment now being under working test. The association is being honored by a paper from Mr. Orwig of The Reeves Brothers Company telling how the kiln and cooler welding was handled, so I will not mention this further.

During the summer it was decided to weld a 50,000 cu. ft. gas holder to be built at Tulsa, but difficulty was experienced in arranging for the steel to be prepared in a manner considered necessary for oxy-acteylene welding. So the welding of a holder was held in abeyance and then allotted to the Linde plant at Columbus, Ohio. This holder is just being completed.

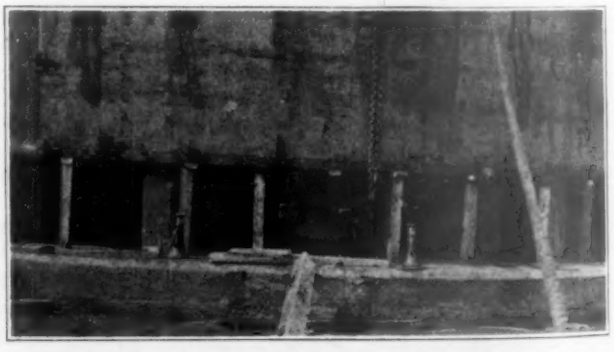
The magnitude of this undertaking is indicated by the fact that the water tank, being 53¼ feet in diameter by 26½ feet high, has a storage capacity over ten times that of each of the Uniontown oil tanks. Were the Columbus tank filled with oil, it would hold 10,750 barrels.



How First Row of Side Sheets Were Hoisted in Position.

Speed of construction was, of course, a matter of utmost importance, so as large a crew as seemed capable of steady work was selected from the Linde Sales Service operators, a supervisor and seven welders being assigned. Arrangements were also made to employ local welders as fast as qualified men could be found. In view of the success in organizing a crew of half a dozen welders for the kiln job in Alliance, it was not anticipated that there would be trouble to obtain welders in Columbus. There were plenty of applicants for the work but only two welders qualified out of twenty-five or six who were tested. This difficulty did not seem to be due to the pay offered, although a couple of the applicants felt that the rate was too low.

This association should certainly be keenly interested in these



Method of Clamping First Row of Sheets.

experiences with personnel because the ability to find qualified welders is of prime importance to a contractor undertaking to do a large welding job. In the Columbus district the natural gas pipe line companies have experienced the same difficulty we did.

Welders were finally located—one at Cleveland, one at Elyria, two at Pittsburgh, and one was generously loaned to us by The Logan Natural Gas Company of Columbus. These men, added to the two Columbus welders and a part of the original Linde

*Paper read before the International Acetylene Association at Chicago, November 14, 1923.

†Consulting Engineer for the Linde Air Products Co.

Completing the First Row of Plates.

crew, gave us ten men besides the supervisor. Unfortunately for a complete test of our ability to keep such a gang steadily at work, the full crew was only built up in time for work on the bell or holder part.

Plans for the holder were made by The Linde Engineering Department in cooperation with the Cruse-Kemper Company, which had built several riveted gas holders for the Linde Company. The Cruse-Kemper Company also assigned a very capable foreman to aid in the work and to follow it up for the benefit of his own company. Mr. Kersey's experiences in building gas holders was invaluable in setting up the blocking for the bottom, in handling the steel plates, lowering the bottom and first ring after the test, attaching the "walk around," standards, guide rails, etc.

The design of the gas holder was based on a few major principles: Plates should be cut at the rolling mill as nearly as possible to exact size so as to fit together for butt welding. Steel was to be as nearly standard as possible to prove that special difficulties need not be anticipated in procuring materials. Quality was Grade A Open Hearth. Sizes were readily obtained from Ryerson Company. Shearing tolerances were quite satisfactory insofar as our specifications called for plus or minus ⅛ inch on either length or width, but all meeting edges to be perpendicular.

The method of construction was also intended to follow some important principles; namely, the bottom plates would be tacked

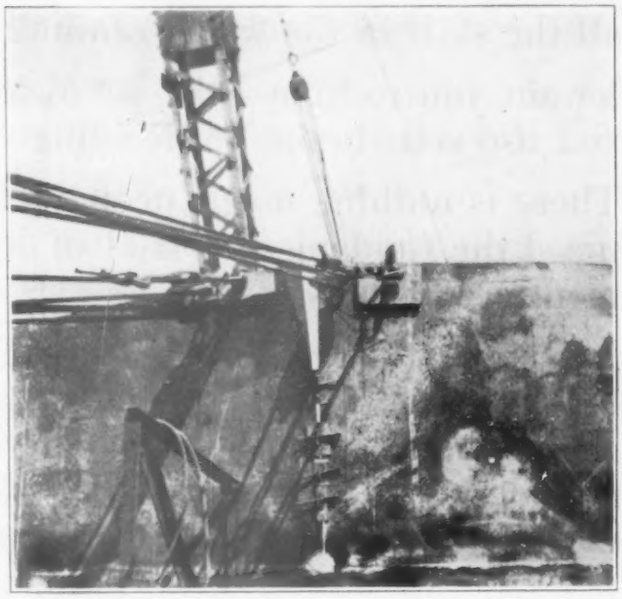
Lowering Tank to Foundation.

together; an angle curb would be tacked to the circumference of the bottom plates; the first course would be completely welded to the curb and the plates welded end to end to establish a complete ring 4½ feet high and $\frac{5}{16}$ inch thick. Then the bottom was to be welded so as to lock up stresses into the first ring and in that way overcome buckling which occurs when welding unrestricted plates.

The principle to be followed when erecting side plates was that all seams were to be made with plates opened at the unwelded end so that there would be an outlet for stresses. It was soon found, however, that it would be difficult to keep a big crew of welders busy if horizontal seams were so welded, since only one man could weld on one seam at a time. There was, therefore, an important modification in principle necessary to make the welding practice conform to economic requirements. Incidentally the method developed gave excellent results, and it is to be recommended for the next work of like nature.

The method of handling vertical seams is to follow the original principle just mentioned and has given excellent results.

The concrete foundation was completed and the bottom plates were laid upon boxes. These were of a type in common use by The Cruse-Kemper Company and were 28 inches in hight. This height allows reasonable freedom of movement for men work-



Refractory Vertical Seam.

ing under the tank bottom. The "key-plates" were first set in place upon the boxes and tacked. After the plates were tacked, the boxes were moved with the exception of those under the "key-plates," which were not disturbed until destroyed. After the boxes were moved, "pig boards" 28 inches high were placed under the sheets, from eight to ten being required for each plate.

"Pig boards" are made by nailing a piece of one by ten inch plank to the edge of a similar piece so that the long sides are perpendicular (like an angle iron). This shape of blocking braces against sidewise pressure tending to upset the blocking, and the method of nailing the pieces permits easy destruction of the "pig boards" when the bracing is to be removed and the bottom lowered.

After the bottom plates were tacked in place the circumference was checked by means of a home-made scribe. A little trimming with a cutting torch was needed and then the angle iron curb was checked for curvature and tacked in place. When the bottom and the curb was completely tacked, there was some buckling or unevenness, but this was not as pronounced as it was after the bottom was completely welded. The maximum variation then was plus or minus 5 inches. This sounds like a good dal, but we may feel better to know that a tank bottom recently welded with the electric arc was plus or minus 8 inches. Furthermore, we believe that the next oxy-acetylene welded bottom will be much nearer flat than the one at Columbus.

The first row of side sheets and a good many higher ones were hoisted into position with "A" frames, as shown in Fig. 2. One end of the seam was left open to allow for contraction of

A Word t

WELDING is not an easy job.

It is hard work—and it takes brains. Every weld you mak requires planning, thought and skill.

But first of all, you must use your brains in selecting your equipment, fo all the skill in the world cannot make a good weld with poor equipmen

I want you to know why we make Rego equipment the way we do, and le you use your brains in deciding whether or not we are correct.

There is nothing magic or marvelous about Rego. We have simply recog nized the fundamental laws of high pressure gases, and built our equip ment accordingly.

An oxy-acetylene flame requires for its complete combustion 2½ volume of oxygen for each volume of acetylene. Of this oxygen, 1½ volume should come from the air, and only the remaining 1 volume from th cylinder. In other words, the oxygen for which you pay should be used i exact ratio with the acetylene—one part of oxygen for one part of acetylene

Rego torches are constructed so that they use exactly equal quantities o oxygen and acetylene.

The proper working of an oxy-acetylene torch requires that the oxygen b under the lowest possible pressure. (Granjon & Rosemberg, Chapter 6. Thi book is internationally recognized as an authority on the oxyacetylene process)

The Rego principle of gas mixture *is the* principle of low oxygen pressure the oxygen pressure in a Rego torch being slightly less than the acetylene pressure. Incidentally, this is the only sure method of eliminating th annoying flashback. This principle is covered by basic patents.

Torches should be strongly constructed and given stringent tests to insure the purchaser against defects.

Every Rego torch is given an actual working test before leaving the factory.

Regulators should deliver an ample supply of gas at constant pressure.

THE BASTIAN-B
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the Welder

It has been proven in laboratory and actual use that Rego regulators maintain a uniform high or low pressure at the outlet and deliver the desired constant volume.

In using high pressure gases, precautions should be taken to prevent accidents. Regulators should therefore contain safety devices which will prevent any possibility of damage in case of careless handling.

Rego regulators have a patented seat and nozzle construction which prevents ignition of the seat should the operator suddenly turn the full tank pressure into the regulator with the adjusting screw turned in.

The diaphragm shearing device (patented) makes impossible the disastrous bursting of diaphragm and bonnet in event of accidental excess pressure in the body.

The gas itself closes off the gas flow in a Rego regulator. When there is a tendency for the gas to creep past the seat, the pressure caused by this gas forces the seat tighter against the nozzle and thus shuts off the flow. There is no possibility of damage because of worn out or lifeless springs.

It is our determination to always maintain our position as leader in efficiency and adaptability in the welding field. Rego engineers are constantly searching for ways in which to improve oxy-acetylene equipment, and the results of their labor are apparent in every piece of Rego apparatus.

In short, it is the policy of the Bastian-Blessing Company to succeed thru applying to the design, production, sale and service of Rego Welding and Cutting equipment those old fashioned fundamentals which form the basis of every permanent success.

The Rego line contains an outfit, torch or regulator for every sort of work, or class of shop in the industry. Our engineers will be glad to give you their suggestions for the solving of your particular problem.

Charles L. Bastian
PRESIDENT

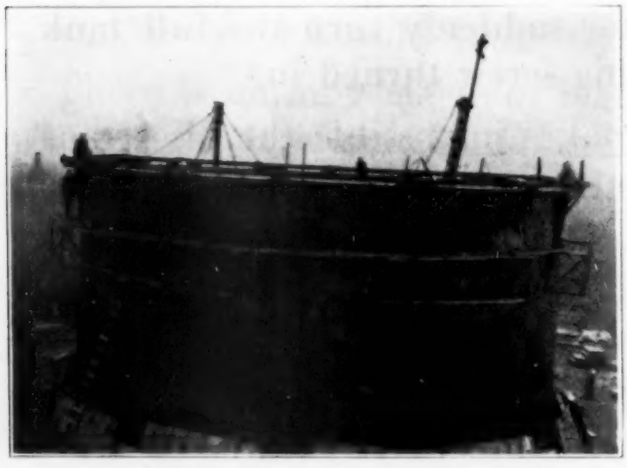
SING COMPANY
, Chicago, Illinois

the weld, but only one welder could work at a time upon such a seam.

The plates were lined up by means of clamps made by slotting a three by five inch piece of quarter inch plate set in the seam and secured by a plate and wedge on each side. These clamps are shown clearly in Fig. 3. At first the vertical seams were lined up by a special clamp, but it was later decided not to clamp the vertical seams while working on the horizontal ones.

The preliminary method of tacking with a small crew of men did not give good results, as the plate pulled or distorted as the tacking progressed. Better results were obtained when a larger crew of men made the tacks in the seam simultaneously and this method was adopted as a standard practice for the upper four rows of the tank.

After the first ring of plates and the bottom was completely welded, the "pig boards" and boxes were knocked apart and the bottom allowed to sag down upon the foundation. A layer of sand and cement covered the foundation under the bottom. While the tank was being lowered in this manner, considerable twisting occurred, as shown in Fig. 5, but it did not in any way



Completed Water Tank at Level of "Walk-Around."

damage the welds. Just before lowering the tank it was tested with twelve inches of water which showed up one slight leak and about ten sweat spots.

Fig. 6 illustrates a method for making a rather refractory vertical seam open up to have the correct space of 1½ inches at the top of the 4½ foot seam. After this procedure the weld

Beginning the Bell.

was completed and it was straight and true.

The complete water tank with the "walk around" is shown in Fig. 7. No great difficulties were encountered in rounding out the tank shell and setting the "walk around," which is riveted in place at the top, but has the standards and guard rails tacked to the side of the tank.

The beginning of the bell is shown in Fig. 8, the bottom angle of which was bolted to the lower edge of the first course of plates. The bell was built by welding at the level of the "walk around" and was lowered by twelve lowering screws, as each row of plates was completed. This welding procedure permitted the welders to keep steadily at work while the guide rails inside the tank and the bottom rollers of the bell were being attached and adjusted.

At present the welding has been practically completed and the tank is under final test. A great deal has been learned about satisfactory preparation of materials and suitable methods of procedure which should aid materially in the future construction of similar holders and large tanks.

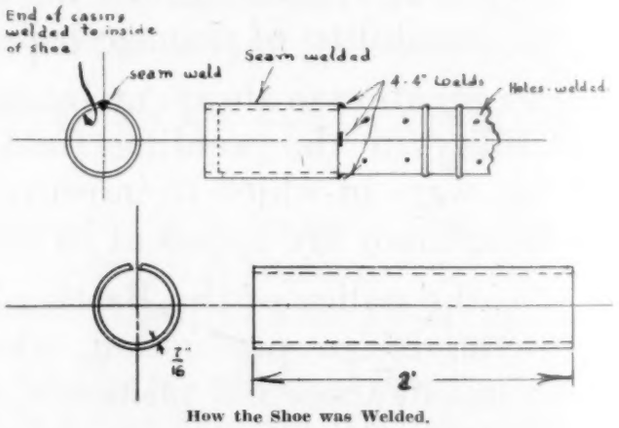
ARC WELDED OIL-WELL CASING

(Continued from page 19)

"shoe" and a "guide." Both are entirely welded. The "shoe" is of 7/16-in. iron and is pulled tight by the use of a chain and a bar, tacked, then welded as shown in the drawing.

The "guide" is cast-iron and, as its name designates, is for the purpose of maintaining the drill in a central position. When the drill passes this point, the guide is smashed to pieces. Considering this, it might not seem necessary to strive for a good weld on the guides. But as these casings are delivered by truck at distances of 20 to 400 miles, a strong weld is needed to stand the rather rough treatment it receives en route to the field.

The welding of the "guide" to the casing is a cast-iron to steel weld. Four 1-in. holes are drilled through the casting about ¼ in. from the hub. The guide is then placed in the end of the shoe and held while tacked. The holes are then welded and the weld is extended to the shoe. In this weld the welded hole acts as a hook. To my knowledge, no guide has ever fallen off. In fact, there have been complaints about meeting difficulty in knocking off the guides in the field.



How the Shoe was Welded.

While in all this, we have attempted to show where and how easily welding can be applied to this line of work. The question must arise as to the ability of this arc welded casing to "stand-up" in the field.

There have been instances where this casing has pulled apart. There is in the yard at this time a 13-in. casing which broke at 575 lbs. pressure. The seams just opened up for a distance of about 2 ft., when it was stopped by one of the 2½-in. lap welds. In fact, so strong was the force behind this break that upon reaching the weld the break was deflected, tearing the pipe across for about 8 in.

In explaining this, we can only say that the seam being the weakest point, would naturally be the first to "go" under an unusual strain.

There is also the possibility that the lap welds while strengthening the seam, must have a certain tendency to shear the rivets.

While the shearing stress is there, the few cases of breaks does not seem to indicate that it seriously affects the strength of this arc welded casing.

Some Chemical Aspects of Welding*

Chemical Changes Produce Great Differences in Properties and Composition—Principles of Oxidation and Reduction

By J. R. Booer

General—Physical Phenomena.—It has frequently been stated that welding is an operation in which it is very easy to obtain indifferent results, and very difficult to obtain uniformly good results. Months of specialised training are necessary to produce an expert welder, during which time considerable specialised knowledge must be acquired, and this knowledge cannot be complete without a thorough grasp of the chemical aspect of the materials and operations concerned. The chemical aspects of welding have been discussed in varying detail in most manuals of welding, yet to the writer's knowledge no attempt has hitherto been made to collect this information in comprehensive form, nor yet to convey the complexity and diversity of the chemical problems which have confronted research workers and those manufacturers who set out to supply the needs of the welding industry. It is the chief object, therefore, of this paper to present this data and to emphasize the importance of what might be called the chemical side of welding.

Before actually dealing with the chemical side, it will not be out of place to make a brief reference to the physical phenomena which accompany welding, namely, fusion, surface tension, diffusion, and expansion and contraction.

Fusion, the medium of autogenous welding, is the change from the solid to the liquid state. For pure substances fusion takes place at a definite temperature, but impurities or other constituents may cause great variation in the melting point. Fusion is always accompanied by the absorption of heat and the quantity of heat necessary to convert unit weight of a solid substance into the liquid form without change of temperature is called the Latent Heat of Fusion. This quantity is of great importance in welding, as this, together with the melting point of the metal, has a bearing on the position of the blowpipe or the current and voltage conditions of the arc.

Surface tension is a property of all liquids and its effects are equivalent to the presence of a hard skin on the surface of the liquid. That liquids have a surface tension can be demonstrated by placing a needle coated with oil carefully on the surface of water. Not only will the needle float, but its weight will depress the surface of the water so that the needle will lie in a hollow. Surface tension has to be overcome before a complete weld is obtained. The presence of oxide generally causes an increase in the surface tension, and suitable fluxes cause a decrease, thus facilitating the operation. On the other hand surface tension becomes an imporant factor in "overhead" welding. For example, in welding steel with the oxy-acetylene process the surface tension of the metal is high, which is good for overhead welding, whereas the surface tension of the slag is low and therefore bad for overhead welding. In the case of cast iron the surface tension of the metal is low and that of the slag high. Any welder knows that it is practically impossible to make an overhead weld on cast iron if a good flux is used, because the flux produces a slag melting at a low temperature and thus exposes the metal. In downward arc welding with a long arc, the forces of surface tension and cohesion tending to retain the globule at the electrode are overcome by the weight of the globule; on the other hand, when using a short arc the forces of surface tension and adhesion at the plate surface assist the gravitational force in drawing the globule to the plate. In overhead welding with a short arc the forces of surface tension and adhesion at the plate overcome the combined forces of gravitation, cohesion and surface tension acting to hold the globule to the electrode surface.

Diffusion is the natural tendency of substances in solution to distribute themselves uniformly. The subject of diffusion of metals in metals has been closely studied. Diffusion occurs in welding in two ways. If the composition of the deposited metal differs from that of the base metal, diffusion will take place, tending to equalise the difference. Similarly, if any ingredient is removed by volatilisation or oxidation, diffusion will again take place. In either case, the composition in the vicinity of the weld will not be identical with that of the base metal.

The property of expansion and contraction of metals on heating is well known, although it is not generally realized that in welding operations the forces of expansion and contraction cannot be successfully resisted mechanically. Where the forces are not free to act they manifest themselves by distortion and failures, and the problems arising out of these phenomena are peculiar to every piece of work and should always receive careful attention. The methods commonly employed to equalise or control expansion and contraction stresses are partial or total preheating, heating restraining parts, bending or dishing, etc., etc.

Having briefly dealt with the more important physical aspects of welding which relate to changes of state or condition, we now come to the changes of composition which lie wholly within the realm of chemistry. It is obvious that the net result of physical changes is comparatively small once the metal returns to the normal temperature; yet the chemical changes, as will be seen later, produce great differences in properties and composition, and these are permanent. It must also be admitted that the ultimate object is to produce no chemical change, but this goal cannot be attained unless the possibilities, the intermediate stages and the necessary remedies are fully appreciated.

Oxidation and Reduction.—The principle which governs nearly all the reactions involved in welding is the principle of oxidation and reduction, and it is much to be regretted that many welders refer indiscriminately to "oxide," "deoxidizing" and "carbonization" without comprehending the true significance of these terms, and without understanding their mutual relationship.

In its simplest form oxidation is the process in which oxygen combines with a metal to form an oxide; similarly, reduction is the process in which the oxygen is removed from an oxide, the metal being liberated. There are, however, varying degrees of oxidation and reduction, and any transition from a lower to a higher state of oxidation constitutes an oxidation. *Vice versa,* a transition from a greater to a lesser degree of reduction is an oxidation process. Thus in carbon steels, if a certain amount of iron carbide is converted into metallic iron, oxidation has taken place although no oxide of iron may be produced, and when steps are taken to prevent decarbonization, it should be regarded chemically exactly similarly to the prevention of oxidation.

Oxidation and reduction always take place side by side and exactly to the same extent. It therefore follows that a reducing agent will combat the effect of oxidation, but it must be remembered that in reducing, the agent itself becomes oxidized, and the nature and chemical properties of the compound so produced must always be considered.

From the point of view of welding we have to consider the metal itself as the neutral point in the scale of oxidation and reduction. This is most unfortunate, for in the wider chemical sense the metals which the welder generally handles are by no means the true neutral points. It should be mentioned that this neutral point varies according to the element. Thus for

(Continued on page 44)

*Paper read before the Institution of Welding Engineers, London, February 12, 1924.

The Welding Engineer

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L. B. Mackenzie.....President and Editor
H. S. Card.....Associate Editor
R. L. Miles.....Associate Editor
W. W. Brothers.....Associate Editor

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Try This on Your Welders

IT is one thing to decide that testing welders every week or every fortnight is good for general results, but it is quite another thing to make them like the idea. Put it on a competitive basis and there will be more fun in it. Have a real fine weld made on a small test bar, break it in a vise, paint it with a thin, transparent varnish and hang it up in a conspicuous place, with a placard announcing that this is a "darn good weld." The chap who will not sooner or later try to duplicate it isn't a good man to have behind the torch or the arc.

What's in a Name?

QUITE a lot of objection has been raised to the use of the word "burning" instead of "cutting," as the process is popularly called in this industry. It is said that one should never "burn" metal, nor even say the word "burn" within heating distance of an oxy-acetylene torch of any kind. This may be the cause of some of the poor work that's done with the cutting torch. "Cutting" is a mechanical term. Cutting is done with gas. "More gas, more cutting," thinks the operator, and proceeds to waste it. It is someone's duty to tell every cutting torch operator that the process is a chemical rather than mechanical one and that his problem is to find out how much oxygen can be combined with his metal to make the "cut," and stick to that pressure which gives the most rapid combustion. He'll understand better the fallacy of too large pressures if he knows what actually takes place.

Shop Bulletins

A FEW pieces of board and a small piece of window glass, plus a few moments of spare time, will fix a place for bulletins, trade paper articles, manufacturers' charts and instructions, material specifications, etc. When tip sizes are wanted they can be located without delay and helpful operating hints are given several readings. It isn't any trouble to find things to post on such a bulletin board and to keep it changing often enough so that it gets almost constant attention.

The Right Attitude Toward Welding

GETTING away from the once popular idea that welding is simply a matter of using a simple tool, one of our largest railroads has gone to a great expense in issuing an elaborately illustrated manual of standard practice. In the introduction to general instructions are these significant observations: "In order to obtain the desired practical and profitable results which can be reasonably looked for, we realize that the operators must understand the first principles of the operation of the necessary apparatus, also know the fundamental characteristics of the various metals encountered during the welding processes. With proper instruction, the operators will cease attempting to accomplish the impossible and thus eliminate many of the failures that reflect unfavorably upon the process involved which tends to retard the progress of the process. Operators and supervisors will please familiarize themselves with the approved standard welding and cutting practices set forth in this manual." In other words, learn how to get the best results on the jobs that are to be welded, and learn to let alone the jobs that shouldn't be attempted. It is important that a large railroad recognizes the need for such advice, for it will result in better satisfaction with welding on that road, and, eventually, to more railroad welding.

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The Cutting of Steel in Scrap Yards

Problems Which are Characteristic of Scrap Yard Work—Difficulties in Way of Estimating Costs

By B. Heyman

THE above title is self-contained and requires no definition. Neither does it require a lengthy introduction, as it is a familiar process—the reduction to smaller pieces, of large steel fabrications or of massive unwieldy castings—and is being performed daily in a multitude of places. At the present moment it has become the fad to specialize in the destruction of such steel ships—battleship or merchant marine—as have outlived their usefulness, or have, due to one reason or another, been relegated to the junk pile as worthless.

In the steel foundry the torch has supplanted the older methods of removing surplus material from the main body of a casting, and, by its adaptability to the most unusual problems that develop in the removal of the heavy risers, it has made of itself an indispensable tool.

Wartime problems are of little interest to us now—that is, such questions as the production of shells, projectiles, etc.—yet the method of nicking billets has been adapted to peacetime industries and is of the utmost value where the operation is carried out.

It is difficult to see how any of this work could possibly be performed, with any efficiency, were it not for the blowpipe, using the various gases, oxygen, acetylene, hydrogen, or any one of the numerous combustibles that are at hand. And yet, the memory is still fresh in our minds, when no such convenient device was at our disposal, ready to be employed at a moment's notice for the solution of some perplexing problem. Drilling, chipping, sawing,—in fact any mechanical method that could possibly serve the purpose was utilized. And yet how clumsy and laborious all of them were!

Only so short a time ago as 1916 one of the largest machinery manufacturers in the East was so skeptical about the process that even a carefully staged demonstration failed to convince the management that here was a means for conserving time, energy, and money; and at a time when every man and machine was busily engaged day and night in the production of wartime materials. This particular problem in this case was to manufacture cylinders for a certain type of duplex power pump for very heavy duty. These cylinders were to be machined from solid billets 9 inches square and 36 inches long, cut from lengths approximating 30 feet.

Strange to relate, the engineering department of this concern, acting according to the policy noted above, ignored the cutting blowpipe and resorted to old-fashioned methods. The billets were drilled from one side and then from the adjacent side, so that the section became a honeycomb of holes perpendicular to each other. Wedges were then inserted, and, by means of heavy sledges and plenty of muscle-grease—manual labor was not at that time exacting high wages rates—the required lengths were severed. It required almost 12 hours to cut one of the lengths, most of the time being spent in drilling—and it is well to consider that this shop was filled with other rush orders which were held up, because so many drill presses were busy doing what one skilled operator and a cutting torch could have performed in an inappreciable amount of time.

Steel, due to its peculiar physical properties cannot be converted into smaller pieces by such methods as are employed in the case of cast-iron—use of the skull cracker, sledgehammer, etc. Its malleability and high ductility permit it to take shocks and bend without any tendency to rupture, and, where the material is of any thickness at all, ordinary methods produce no result, in direct contrast to their effect on cast-iron of similar thickness.

For this particular reason, it appears how dependent the larger industries have become for their sources of certain materials (or rather a large proportion of their supplies) upon the many scrap-yards that are daily storing up the steel "junk" and preparing it by cutting, for shipment to the factories and mills, where this steel scrap is melted and converted into new material for various uses.

The sizes into which the steel is cut depends entirely upon its ultimate disposition. By this is meant the specific company which is to do the remelting. Rigid specifications imposed by the mills must be adhered to by the scrap dealer, not in order to put limitations upon the man who cuts the steel, but to provide for the steel being prepared so as to fit whatever charging box may be in service at the mill. The commonest size runs in the neighborhood of 5 feet by 2 feet, although this does not hold true in all steel mills.

"Waste Trade Specifications" give the following examples taken at random:

"Railroad steel and heavy steel croppings from rails, billets, blooms, structural shapes, plates, bars, rods, channels, angles, plate shearing from steel plates—(not needle, scrap or skeleton scrap)—steel rolls and other similar material. All charging box size, not over 6 ft. in length, or 18 in. in width, and not lighter than ¼ in. thick. Minimum weight 10 lbs., maximum 300 lbs."

"Must consist of "T" and girder rails, splice bars, boiler plates, car springs, axles, angles, beams, channels, drawheads, (steel) knuckles, (steel) steel castings, locomotive tires, bar mill crops, all broken to charging box size. Not over 5 ft. 6 in. long, 19 in. wide, 27 in. high. Weight not to exceed 600 lbs. per piece."

"Heavy melting steel, soft axle ends, structural shapes and merchant bars. No single piece to weigh over 150 lbs., nor more than 10 per cent to weigh less than 5 lbs., and not to exceed 3 ft. in length, 12 in. in width nor be less than ¼ in. in thickness."

For export shipment it is of the utmost importance, that the steel be in such shape and size as will occupy the least cubic content in a ship's hold for the maximum of weight. Handling must also be reduced to a minimum, therefore the pieces are cut in long but comparatively narrow lengths,—approximately 25 to 30 feet long by 5 to 6 feet wide. Upon unloading at the destination, such pieces can be cut transversely into proper charging box sizes with a minimum of labor and expense. A great number of scrapped ships are going by this route, also a large quantity of fabricated material which is lying in the many neglected shipyards, including keels, hull parts, etc.

Naturally, the scrap dealer is influenced in his choice of size by a number of factors. The prices he is to receive for his material, the price he has paid for it, and the costs of cutting, handling and transporting it are the governing ones. Actually, however, these all hinge on the ultimate consumer of the scrap, either because of his process or other limiting conditions—charging box, crucible, etc.

Where a large industry has begun to specialize in semi-steel or in light steel castings and requires a steady flow, in small quantities, of a scrapsteel cut to say 3 feet in length and in weights not above a single normal man's capacity, that industry will generally pay a premium for good clean material that meets with its approval. And the extra cost of cutting to this smaller size is generally offset by the additional payment per ton for the product.

On the other hands, the majority of scrap dealers can find no such outlet and must content themselves with shipping in carload

lots to the steel centers. In such cases it is customary to accumulate large quantities of the material and await a rising condition of the market price, when they unload.

Fluctuations in the market price occur from day to day and are of unusual interest to the dealer. Yet these fluctuations should in no way concern him as regards the cutting and preparing of his stock in trade. Cutting costs do no vary because of market values paid for scrap steel. Labor, and gas costs are very uniform the year round, so that, viewed from this angle, cutting is permissible the year round and even though the price of steel may be low one day, the next day it may take a turn which will make an accumulated stock represent a small fortune.

Cutting costs are affected, however, by numerous other conditions, and these will be discussed in the following paragraphs. Under proper guidance and supervision many of the difficulties encountered in scrap yards are possible of elimination.

If there is any place, or any work which produces more complaints regarding apparatus, than the scrap yard, it has yet to be discovered. Regardless of the fact that such apparatus is built under the most careful inspection methods, by experts using tested materials and to a design that is well nigh perfect, yet it does not require lengthy service in the hands of an incapable operator before the equipment is back for repairs. The fault is not inherent in the apparatus. Neither does it lie in the manufacturing methods. Such apparatus is always tested and inspected before delivery, and is known to be in perfect condition.

But, put such apparatus in the hands of a "hunkie" and tell him "to go to it." Let him work around a pile of steel for a few days. Then the fun begins. Leaks of various sorts are the most prevalent evils. Burnt hose caused by dragging against almost red hot steel are next in order. Burnt tips, damaged gages, plugged regulator orifices are brought to the attention of the manufacturer as though he were to blame, when, in truth, the fault lies in the methods employed on the job. The scrap dealer, except in a few instances has not come to a realization of the fact that an operator must know quite a bit more about his apparatus than merely "to press the button and blow out a slot."

Regular inspection for leaks, etc., care in handling the regulators and torch, proper taping of the hose and a little attention to where it happens to drop will all serve to lengthen the life of the equipment and materially aid in getting the best out of it. The equipment is not comparable to the other tools in use in scrap yards—sledge hammers, pinch bars, etc.—and cannot be treated in the same fashion as these. The sooner the operators appreciate this fact, and act accordingaly, just so much sooner will come an alleviation of one of the scrap dealer's burdens (upkeep of apparatus), and of the manufacturer's bugbears (complaints).

Weather conditions (mainly the temperature) cause decided changes in the quantity of work that can be turned out. Seasonal changes affect the process directly. When cold weather sets in, it is to be expected that slow progress will be made, in direct contrast to the normal speeds possible during warm days. Lower temperatures are effective, not only in keeping the steel at a proportionately lower temperature—but to this weather condition is traceable much of the difficulty encountered in the use of gases under pressure, which are expanded through a small orifice. The expansion of gas under these conditions causes instantaneous freezing of any water present. Alternate obstructing and clearing of the small aperture occurs and is discernible in the fluctuations of the low-pressure gage on the regulator and also in the manner in which the cut progresses.

Until recently this state of affairs was very common to all outside work. Now, however, through more perfect design and care in manufacture the difficulty has been practically eliminated, although it is still a disturbing factor in some of the cheaper grades of apparatus that are distributed to the unwary.

How the temperature affects this type of work can best be illustrated by a specific case, one in which a concern contracted to cut several thousand tons of steel. An estimate made during severe winter weather gave a price (actual cutting was performed) that was acceptable, owing to the high price which could be commanded for this kind of steel. Later when mild weather set in, it was found that this estimate could be bettered almost 10 per cent and the cutting cost was further decreased when the hot summer days arrived. It was remarkable how the heat from the sun's rays, stored up in the steel, aided the progress of the torch.

The effect of inclement weather on the operator is in itself an unusual handicap, due to the unusual requirements of the work. When a man is compelled to crouch for long intervals, without protection from climatic severities, and manipulate a blowpipe, he undergoes a terrific strain which is readily noticeable. High nervous tension and physical and mental fatigue ensue.

Possibly he may conserve his gases by unusual care, but no matter how skilful or conscientious in his application to his task he can hardly cope with these obstacles and work with any semblance of normal efficiency.

On some types of work great economies can be effected by utilizing simple devices that eliminate hand control of the blowpipe. To hold a torch steadily for long intervals is a trying task, although it can be mastered by zealous application and careful attention to details. Yet, one of the most difficult requirements on the cutting job—perhaps this may not appear so to the average cutter—is to move the torch at a rate of speed which keeps the oxide blowing through, so that a minimum of oxygen is used, and at a rate of speed which is a maximum, without losing the cut or failing to penetrate completely. On plate cutting, to illustrate, straight line machines are an indispensable accessory.

When the work of cutting a large quantity of 3 inch armor plate at Sandy Hook was undertaken in 1919, one of the first engineering problems to be decided was the design and construction of a torch holder and mechanism to operate it over the curved and warped plates. This was plate cutting of an unusual kind as each piece has been pierced six times by large projectiles which had left their mark by pulling a large section into a radius leading to an opening. It was necessary that the torch follow the uneven surface of the plate and yet keep the preheating flames and oxygen jet at a uniform distance from the surface. A very simple machine was made from a phonograph motor using an adjustable friction drive and jointed flexible steel rods to draw the torch carriage over the plate. How successfully this apparatus functioned was described in a previous article in *The Welding Engineer*.

At the present time there are several methods of producing oxygen for use with the blowpipe, all of them turning out a gas that has a purity closely approaching the standard of perfection. Absolute purity would be the ideal but this is hardly practicable as in the one method a slight trace of nitrogen may be present without causing any effect and in the other processes hydrogen, etc., may be carried over in identical fashion.

Although a great deal may be said for the various methods in use, this should hardly concern the consumer, as the product normally holds to a uniform standard and it is a rare occasion where the impurities are present to a degree that will be noticeable. Yet, there is always the possibility of a mishap for which the charging company cannot be held responsible and which may result in one or more cylinders being sent out with a content that causes the scrap dealer an unusually high cutting cost. It is not surprising that the cutter can offer no fitting explanation for what is apparently a lack of skill. Even an expert, familiar with every possible cause and its effect, could only hazard a guess. Only an analysis by careful laboratory methods would determine with any finality that impurities were responsible.

Accessibility of the material has an important bearing on the quantity that can be prepared in a given time. Ease in attacking a tangled jumble of steel scrap always counts in the long run, although most yard men who are responsible for the placing of

(Continued on page 40)

POSSIBILITIES OF ELECTRIC WELDING*

Variety of Jobs Which May Be Handled on a Production Basis—Arc Welding and Resistance Welding Included in This Discussion

THERE was a time when the wearing of a fraction of a cubic inch of metal from one of the wearing surfaces of a piece made it necessary to scrap the part with a consequent loss of material and labor investment. It was only after the introduction of the fusion welding processes that it became possible to stop this economic waste. By spending a few dollars for welding it is sometimes possible to save parts involving many hundreds of dollars, not only by reclaiming the worn parts, but in savings due to the much less time required for welding than for replacing them by new ones.

The repair of broken members of machines has been another important engineering achievement made possible by the electric, gas and thermit processes. Here, again, there are instances every day where the returns on the money spent in welding are as high as 1,000 per cent as compared with replacing these broken parts by new ones.

Of recent years there has been a strong tendency towards substituting castings made of steel for those made of cast iron. The reasons for this are that the steel castings for the same strength are lighter and less brittle and consequently less likely to break under shock. But, steel castings are more liable to defects such as blowholes than are cast iron ones, and as their cost is higher any process that can reclaim steel castings is of great benefit to the manufacturer. Welding processes are used very largely for this purpose, and have resulted in material saving and doubtless in the extension of the use of steel castings in place of cast iron because of the reduction in cost effected by welding processes.

Very often mistakes are made in machining, and were it not for welding, these valuable castings would be rendered useless. As it is, the only loss is the time and money necessary to deposit new metal by one of the welding processes. Here, again, the returns on the welding investment may be as high as several thousand per cent.

Possibilities of Welding as a Fabricating Process

The manufacturing process of building a large structure by riveting consists of the following:

1. Design.
2. Making drawings.
3. Making templets.
4. Marking steel.
5. Punching or drilling holes.
6. Assembly.
7. Riveting.
8. Painting in shop.
9. Erection.
10. Painting in the field.

At the present time there would be very little saving in the time taken to design a welded structure as compared with a riveted one. This is due largely to the fact that in most cases both would involve the same kind of stress determinations. However, a shop drawing of a riveted structure requires a great deal of time and entails a large expense for practically every dimension is indicated on the drawing, every rivet is carefully located and the size, width and length of every structural shape is given. The amount of work involved is readily estimated when one considers that in a very simple small plate girder railroad bridge there are about 6,000 rivets. A very small fraction of this time would be needed in preparing working drawings for a welded structure.

After the drawings are finished for riveted work, they are sent to the templet shop where full size templets made of wood or heavy board are prepared for each and every piece in such a way that all holes to be finally placed in the steel are indicated in position and size on the templets. These templets are then sent into a shop where they are clamped to the steel, and each steel piece is marked to conform to its duplicate both as to size, shape and location of all holes. These pieces of marked steel are then passed through shearing machines, shearing them to shape and through punches to punch holes. The numerous pieces which make up the girder or other members and which have been cut to shape and punched are now assembled and temporarily bolted together with a few bolts—all the parts and pieces of steel which are in contact having been given a coat of paint.

In contrast to the work involved in riveted structures outlined in the above paragraph, all of it is omitted in the welded structure.

The assembled members, if they are to be riveted, are taken to the riveting machines either fixed in position, in which case the piece to be riveted must be moved in order to bring the rivet in the proper position in the riveting machine or the riveter is portable for use on heavy work, and is so arranged that it can be moved about as the rivets are driven. In driving rivets it is frequently found that because of inaccuracy of workmanship holes do not come exactly opposite but by driving a drift pin the holes are more nearly brought in line before a rivet is driven. Most of the holes in structural steel work are punched, and after being assembled are than reamed to get a smoother and larger hole. On heavier materials or parts where the best results are desired, holes are drilled.

Again, in contrast to the above, in the welded structure the parts to be fastened are held together temporarily by small "tack welds," requiring only a minute or two to make, or by suitable clamps. There are no holes to align, and welding progresses steadily from one end of the seam to the other.

As a general proposition, the riveted or bolted joint has a tensile strength considerably less than the original piece, whereas the welded joint may be made as strong as the original section. Moreover, the welded joint is oil and watertight up to its breaking point, while the riveted and caulked joints leak badly at as low as 25 per cent of the ultimate strength.

Everything considered, it is conservative to state that in most cases the fabrication of steel by welding can be done with a saving of 25 per cent over that of the riveting and with a better quality of product. A saving may not be effected in the first structure, but will undoubtedly be brought about as familiarity with the process and its use is attained by designers, draftsmen and workmen. It should be also pointed out that in some instances the superiority of the finished product would justify the use of welding even though it cost several times that of riveting. A striking example of this is in the construction of oil storage tanks for lighter oils. The present riveted structure is not sufficiently tight for holding these oils, and the savings which would be effected by prevention of the loss of oil from leakage and evaporation would in two years pay entirely the cost of the welded tank. Welding has also recently been used in the fabrication of some large gas holders with a saving in cost and improvement in quality of product.

Arc Welding

Steel companies with vision are already preparing for the time when arc welding will supplant the rivet, and they are gaining experience in its use upon the smaller welded sections, or in minor operations which do not require approval. A mul-

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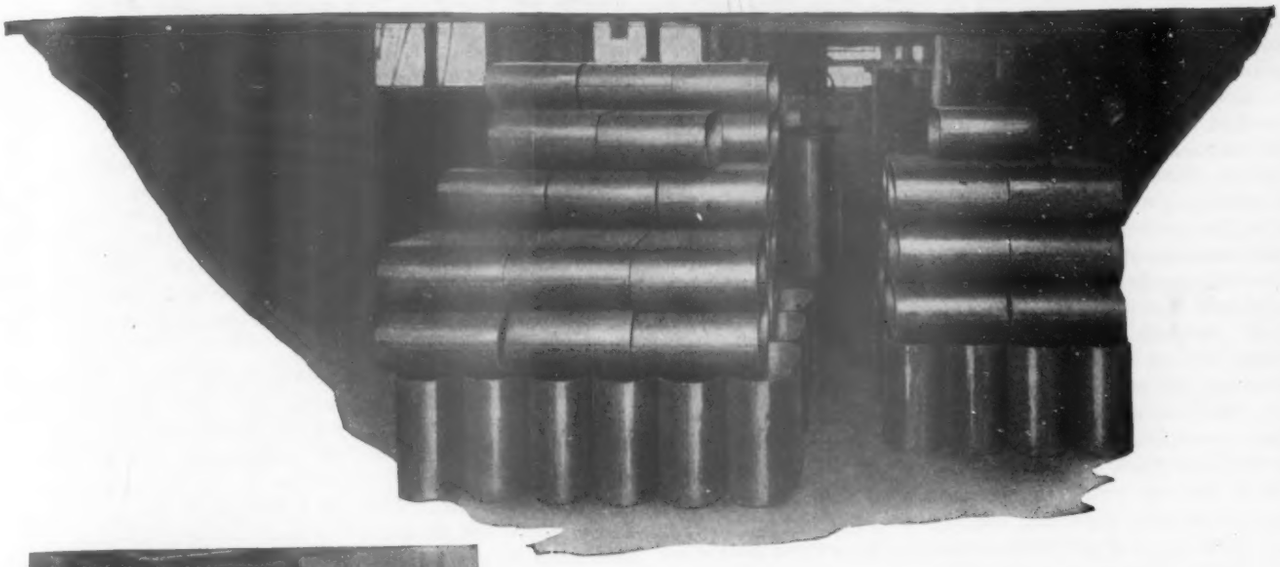
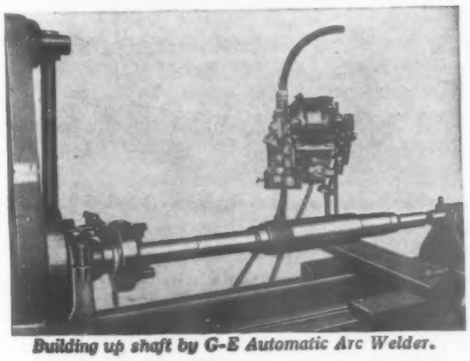


Straight seam welding of tanks by G-E Automatic Arc Welder.



Building up shaft by G-E Automatic Arc Welder.

Automatic Arc Welding

The above picture shows 50 tanks welded by a G-E Automatic Arc Welder in a half day, as compared to 21 tanks welded by the hand method in a full day. The metal welded is 1/8" thick by 24" long.

Through this automatic application of the electric arc, a steadiness of the electrical conditions in the arc is obtained and maintained, resulting in a uniform and high quality of weld—and higher speed. Higher welding speeds produce lower welding costs.

The principal field for the G-E Automatic Arc Welder is the production, by welding, of duplicate objects in considerable quantities.

Its greatest use is for straight line seam, which is the simplest form of weld—but it also does efficient welding of circular seams, and in building up processes on metal.

G-E welding engineers will cooperate with you in making suitable applications of the Automatic Arc Welder to processes of production in your plant. Ask them.

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titude of minor structural firms, and many large ones, have to their great advantage adopted this new tool, as in the automotive industry, the iron and steel works of the country, the engineering and contracting companies, the steam and plumbing industry, including the laying of steam, water and other pipe lines, as well as the two industries that did most to develop the process —the shipbuilding and railway companies.

To the railway companies belongs the credit for sponsoring arc welding in its infancy. Some of these companies have made use of the process for more than 15 years, chiefly as a repair utility, and a detailed list of the specific uses to which it has been put would occupy a volume of its own. As experience shows conclusively that joints stand up without failure, more and more of the fireboxes on new locomotives are being welded. It is the standard practice on many railroads to weld all the flues in the firebox end when the locomotive is built and when they are reset. While these flues would, under constant service, ordinarily begin to leak in about three months, they have withstood leakage for three years when welded.

When the war came, and brought with it the necessity of great increase in speed and efficiency in shipbuilding, electric arc welding was provided with a chance to demonstrate its worth. That it came up to all expectations is now but a matter of record. The shipbuilding industry took over the process as developed by the railroads, and, under the pressing necessity of the nation's need, developed it to a high degree of perfection. This was especially the case in the working out of the fabricated ship idea.

As far as production is concerned there is probably no metal trade or business that will not ultimately come to use arc welding methods, while, for repair work, there is a use for this process everywhere.

In the beginning, the steel industry rather shied at the brilliant light of the arc, and maintained that it could recast broken parts more cheaply than to weld them. Now the recasting is done locally by the aid of the arc. Why recast an entire piece, when you only need to recast the metal around the break or defect?

It was obvious logic, and as soon as it was shown that it could be done the steel companies acquired many machines for the purpose.

There is not a steel mill now in which arc welding is not well known, and the most difficult jobs have been easily and satisfactorily accomplished by its aid. They include the padding-up of worn wobblers which are hardened and smoothed at the same time by the use of the carbon arc; water-cooled fire-door repairs; repairs of bearing breakages and rolling stock; repairs from wear and accident, including special locomotive jobs; repair of miscellaneous breakage and wear such as broken gear teeth, worn keyways, worn armature shafts, misdrilled holes and lack of bosses, in short, a multitude of jobs that can be handled by a "putting-on" tool.

Electric Arc Cutting

Although it is common practice in the steel industry to use gas for cutting, yet there are many places where the electric arc may be used advantageously because of the resulting saving in cost. Arc cutting may be defined as a resultant combination of the melting of metal due to its high temperature, and the oxidation of a portion of this metal by the oxygen of the air. This oxidized portion, because of its lower melting point, acts as a lubricant and tends to slide off the greater masses melted by the heat of the arc.

In arc cutting, gravity must be utilized in that the operation must be performed from the vertical or underside. Many attempts have been made to use oxygen or air under pressure with arc cutting, but it has so far been found impractical to do this. However, the intermittent use of compressed air or oxygen with the arc has been made successful by releasing a stream of air after the arc has made the puddle molten, and by blowing it away upon the oxide lubrication. This method is especially useful in rivet cutting on a top or horizontal surface.

This arc will cut any metal, viz., brass, copper, zinc, lead, cast iron, malleable iron, high carbon or alloy steels, etc. Considering the supply of heat energy necessary, the electric arc process is also cheaper than gas. Yet, for heavy work, the use of the gas method is the best practice because of the speed possible. Moreover, for heavy and careful work, gas can equal machining methods, for which the electric arc cannot be considered. For rough work, however, such as cutting up scrap into charging sizes, or for work requiring subsequent machining, the electric method is the cheaper, providing the thickness of the piece is not too great. For cutting non-ferrous metals, the arc is thus far superior. The arc will efficiently cut the scrap sections of cars, boilers or tanks into charging sizes, and will rapidly cut through sills, channels, or other stiffening members at a rate proportionate to their thickness, but always at the same low cost of power.

For straight arc cutting, the thickness that can be economically cut by the arc is under six inches, and lies between two inches and six, depending upon the price of power and other considerations. For heavier sections, the speed of gas cutting is greater than that of arc cutting, and is the cheaper because of smaller labor costs. There is, however, a method of nicking and breaking, in which the electric arc is more efficient than gas for any size material. In any average scrap pile, the work is more economically done by the electric arc; the heavier sections may be nicked and broken, or cut through with gas.

A striking example of economy is found in rivet cutting by the arc. One man with the arc (where power cost is very small) will cut from one hundred to two hundred rivets an hour.

Resistance Welding

Resistance welding is used in the manufacture of many articles we use every day, including the welding of the stems in watches, the rims of our eye-glasses, the handles of knives and forks, the rims and frames of our baby carriages, our automobiles, rims for truck wheels, handles on wrenches, chisels and hayforks, shanks of mild steel on high-speed drills, reamers and cutters, chains for all purposes and of all sizes. The term, "resistance welding" applies to seam welding, spot welding and also to butt welding.

Seam welding has now been developed so that two ⅛-inch sheets may be successfully welded and the length of seams can be practically anything that can be secured in commercial stock. It can be applied to the manufacturer of steel barrels, casks, tanks, culverts, smoke-stacks, ventilators, conveyor tubes, heating and ventilating pipes, etc. The seams can be made at the rate of 40 ft. per min. on two ⅛-in. sheets and 20 ft. per min. on two ⅛-in. sheets without any previous scarfing or special preparations of stock.

"Spot welding" machines have now been developed that are entirely automatic as regards time and pressure so that the welder functions in the same way each time, and makes all welds alike. One electrode is stationary while the other slides on a carriage which is moved up and down by a revolving cam. A coil spring between the electrode and carriage insures uniform pressure of the work piece and the speed of the cam is such that the electrode is in contact with the work just long enough to secure good fusion of the pieces, probably one or two seconds. A commercial spot welder has now been developed for welding two plates of a thickness of one-half inch.

Through the application of butt welding, steel castings or complicated machine parts are being replaced by either drop forgings or steel stampings in halves and welding these halves together by the resistance method. By this procedure great uniformity of product and light weight may be obtained and while retaining or improving the quality, articles so manufactured can be produced much cheaper.

The resistance welding is distinguished from other welding processes in that it is used particularly for mass production of standard articles to be brought to welding machines to be welded, mostly by semi or total automatic means, excluding as much as possible the individual skill of the operator.

ARC WELDING IN THE TANK INDUSTRY

By C. E. Scheuring*

THE electric arc weld has definitely taken its place as an efficient and satisfactory method of constructing tanks and other products built of steel plates. Certain products, such as arc welded underground gasoline storage tanks, are generally accepted as the measure of quality and each year sees the arc gaining in popularity.

There was much prejudice to be overcome by pioneers in arc welding as the riveted tank had been used for years and the first welded tanks built were not all that was claimed for them. For instance, about twelve years ago a small boiler shop, with which I was connected, received an order for a ten thousand gallon tank. The customer was not particular as to how it was built but naturally did want an absolutely tight tank. A man claiming to be an expert welder had opened a shop near by and approached us with a proposition for welding the tank at such a low figure that he was below our riveting cost, so we gave him an order for the work, and assembled the tank according to his instructions. All went well until his welding was almost complete when difficulties, and many of them, developed. As fast as the girth seam was finished on one side the contraction would split it open on the other side, and, after chasing the cracks back and forth for a week, he gave up, cut the tank apart and we punched holes and riveted the tank. Naturally we both lost money and I lost faith in welding for the time being. Similar experiences scattered throughout the country made people look askance at welded articles, but they are learning that all welds are not alike and that steel work properly designed and welded really furnishes a superior article.

As welding has progressed the art has become more specialized until now we find plants designed for the sole purpose of manufacturing a certain article by means of the welding process that is best adapted to it. In this way the electric arc has taken its place as a proper medium to use in building tanks from No. 12 gauge to 3/8-in. thick. These limits will undoubtedly be varied as improvements in equipment, such as the application of the automatic to the lighter sheets, are made. The possibilities are vast and the arc lends itself to multiple production so readily that where there are standardized articles to be built, costs can be reduced and the public in general benefited.

In the adoption of welding, changes in design have been made and some times an overzealous designer has gone too far. In an effort to save steel the lap joint was discarded when in reality it was an economy to keep it. In the same way the flange on the head was discarded. Regardless of the fact that the manufacturer of the flanged and dished head charges a stiff price for the work, it is more economical to use it than the dished circle with the peened-over shell. It results in a better looking job and is exceptionally strong as proved by the following test.

Two years ago, in an effort to find the strength of the welded longitudinal joint on pressure tanks, a plan which I was managing built three test tanks 20 inches diameter by 3 feet long. The shell and heads were of 1/4 inch tank steel and the heads were dished to a 20 inch radius. Each tank was provided with two openings so that they could be vented while filling with water. The first tank had a lapped longitudinal joint welded inside and out, the second tank was welded solid outside and tacked inside at 12 inch intervals and the third tank had a butt joint welded inside and out. Each tank blew a head out at approximately 1200-lb. gauge pressure because the shell had been stretched from 20 inches diameter to 20 3/4 inches. This expansion of the shell placed a bending stress in the weld connecting the shell and head, which greatly increased the strain at that point. Referring to your rule for finding the strength of a cylinder, you will find that we had a unit stress of 48,000 lbs. to the square inch and, although we did not find the strength of the longitudinal joint, we were quite satisfied.

Welding is often blamed for accidents and failures which are not the fault of the weld but are really caused by a lack of common sense on the part of the person handling the welded article. An excellent example of this was called to my attention some time ago and it illustrates the point so clearly that I will describe it.

An oil dealer had purchased a 10,000 gallon vertical storage tank 10 feet in diameter by 17 feet, 2 inches high. The tank was built of 1/4 inch plate and had a flat bottom head braced with channels. The roof was a cone and had a 2-inch opening in the center for a vent, and a bolted man head. A 3-inch opening was placed in the shell near the bottom for inlet and outlet. The purchaser put a blow off valve on the bottom opening and piped his inlet into the vent opening in the top, pumped in 7000 gallons of oil and then called me to see the "Rotten" weld that had let the bottom "fall out." The above statement was made notwithstanding the fact that the force of the oil coming out had blown a workman 30 feet where he was stopped by a telephone pole. The fractured weld, on examination, proved that it was not at fault inasmuch as the break was partly through the weld and partly through the shell plate.

Electric arc welding as a manufacturing process is comparatively new and there has been little exchange of ideas between the managements of the different plants. Now that it has become more firmly established there will be a greater interchange of experiences and less trade secrecy. Better data will be compiled regarding the effects of voltage and amperage and wire analysis. There are still many prejudices on the part of operators which are not really substantiated by results. The progress so far has really been marvelous and in a very short time arc welding practice will be standardized and tabled, elevating it from an art to an exact science.

Vice-President and General Manager, Emerson-Scheuring Tank Co., Indianapolis.

PORTABLE ARC WELDER

A portable arc welder called the Metweld, and intended for production and maintenance work, has been brought out by the Welding Metals Mfg. Co., Cleveland. It is available in 110 and 220 volt sizes, and has a range of from 50 to 150 amp. in six steps of approximately 20 amp.

The current consumption for the 110 volt machine ranges from 2.7 to 8 kw. The heat can be changed quickly for different thicknesses of work by plugging any one of the six steps with one end of the jumper. A carbon electrode can be used if desired. The welding, ground and jumper cables are heavily insulated and the welding and jumper cables are extremely flexible. The cable terminals are of bronze and protected by vulcanized fibre. The electrode holder is cast brass with a vulcanized fibre. The welder is inclosed in a substantial case and may be trucked without injury. The weight is 165 lbs. for the 110 volt and 190 lbs. for the 220 volt welder.

CORRECTION

The report of the United States Welding Company's welding contest published in the March issue of the *Welding Engineers* contained the name of Baldwin of Wamego, Kan., among the honorable mentioned. This should have been Balderson Welding Shop of Wamego, Kan. This shop is owned by and operated by N. C. and J. W. Balderson, is well equipped and does high-class welding. They have contributed several short welding stories in past numbers of *The Welding Engineer.*

BOILER MAKERS SUPPLY MEN TO MEET NEXT MONTH

The Master Boiler Makers' Convention will be held at the Hotel Sherman, Chicago, on May 20 to 23, inclusive. Exhibits of the supply men will be held on the mezzanne floor and business meetings and entertainments will be held in the Tiger Room.

A TRICKY CAST IRON WELD

How a Clever Operator Successfully Welded a Huge Pulley Without Dismantling, and Got Away With It

Marseilles, France,
Wednesday.

Dear Ed:

Here I am, still in France, only this time I'm away down south on the Mediterranean. The more I see of this country, the better I like it, so it may be a little while yet before I have an opportunity to slip over to Germany. Fate smiled sort of sweetly upon me this week. You can believe me or not but I saw the "impossible" accomplished with a welding torch and I want to pass it along while it's fresh in mind. The whole affair seems to me to have been a dream, but I rub my eyes and I've got to confess that I'm very much awake. Despite this fact, I can hardly make myself believe that what I saw actually took place.

Pulley Wheel Welded in Place.

Besides this, the circumstances were rather peculiar so I'll let you have the whole account.

I landed here Sunday. Had just got squared around and was ambling down the avenue, when whom did I bump into but Pete Moran, a chap I used to know back in Indianapolis. It was a good many years since I had seen Pete and I certainly wouldn't have known him, the way he was all duded up. But he knew me and take it from me, I was so glad to see and talk to somebody I really knew that I almost gave him a Frenchman's greeting, namely, a kiss on each cheek. Was not long in learning that he had forsaken the steamfitting trade to become a welder. Despite two missing fingers, he had enlisted in the war and had liked France so well that he returned and has been working as a welder in one of the big shops here ever since. We spent the balance of the day together and I promised that I'd be down to give his shop the "once over" the first thing Monday morning.

I was there bright and early; it was a good thing too, for otherwise this whole experience would have been missed. I no sooner located friend Pete; in fact didn't even have a chance to gaze around the shop, when one of the bosses came dashing up to him with a slip of paper in his hand. After a hurried consultation, I learned that a big breakdown had occurred about thirty miles away and Pete and another welder were scheduled to slip out there in answer to their "S. O. S." When extended an invitation to go along, I promptly accepted and in no time at all we were on our way.

The fact that Pete had done a little racing in his day, I did not recall until we had left the city. At this hour the road was fairly clear, for the farmers and their carts had passed hours ago, so bang we went just like a bullet from a gun. I never will forget that ride, Ed. In Paris the weather has been pretty damp lately, but here the sun was shining and as we dashed along some of those scenic spots and got a glimpse of the blue ocean, it was much too fine for a welder to appreciate. Soon, however, we arrived at our destination and were met by a couple of wildly excited men. We followed them and were soon viewing the cause of their concern. And believe me, Ed, they had just cause for worrying. Here was an eighteen foot cast iron pulley, with an eighteen inch face, mounted on a twelve inch shaft which had evidently been installed before the building had been erected. The rim was very heavy and the hub was in keeping but the spokes, of which there were eight, were very light. Six of these eight spookes were broken off close up to the hub.

On account of the heavy rim, the lightness of the spokes, and the massive hub, it was very evident that at best, with the most careful treatment after the pulley had been removed and preheated that it would be an exceptionally difficult welding job. For granting that these light spokes were welded and cooled successfully; still the opportunity for warping the heavy hub and thereby throwing the whole pulley out of alignment was so apparent, that it would take a brave welder to tackle the job even under those circumstances.

Suddenly Pete, who had been talking to the two men, gave a shout, threw his hat up in the air and walked out of the room as fast as his long legs would carry him. The two men hurried after him and soon had him back, one on each side apparently pleading with him. Finally he nodded and I thought they were going to embrace him for fair. After giving his helper a few instructions, Pete journeyed over to where I was and I asked him the cause of the outburst.

"Ye Gods!" He shouted, and I could see that he was still a bit put out, "I thought of course that they'd take the pulley off the shaft in order to give us a chance of preheating, but they say that's impossible. That wall yonder would have to be wrecked and the whole machine dismantled. They insist that we weld those spokes just as the pulley now stands."

"They're crazy; the whole thing would crack in a hundred parts if you went after it that way," I said.

"That's just the point," he replied, "but they know nothing about welding, so think it's merely a question of melting the ends of the broken spokes together and letting her go at that."

"But why did they both go away smiling?" I asked.

"Why after I got through telling them repeatedly that it was utterly impossible to even think of doing the job that way, I finally promised to give it a little study and would see if there were any method left which would give us a fighting chance. Guess that sort of pleased them," he ventured.

"Well, what are you going to do " I asked.

"Be darned if I know. First I'll take a little walk and think it over. Want to come along?"

I joined him and off we went, he lighting up his pipe and me following suit. Suppose you're a bit surprised to learn I'm hitting the pipe but a fellow has to over here if he wants to smoke at all; cigars and fags being out of the question, both in price and quality. We had strolled along for about five minutes and not a word had been spoken, when suddenly Pete stopped short. "I've got it!" he shouted. "It's a gamble, but it's worth a try." So we hurried back and after a short talk with the bosses, who were now all smiles, another chap and the helper commenced preparing the job.

After a bit when the apparatus, including the two portable acetylene generators had been all placed and Pete was waiting

for his helper to finish up his end, I had an opportunity to ask him if he'd mind telling me how he intended tackling the job.

"Not at all!" he replied. "Step a little closer here and I'll explain my plan to you. See this spoke we have turned to the top position? That's the one we tackle first. Notice how far the broken ends of that spoke are apart. Almost an eighth of an inch."

"That means that the whole pulley is that much out of true, right now, doesn't it?" I asked.

"Perfectly right," he answered. "I called that to the owner's attention and explained that if there was any chance of doing a successful welding job that the only way would be to figure on leaving the rim just that much out."

"How come?" I wanted to know.

"Well, it's very evident that there were foundry strains or season strains left in those spokes or they would never have broken in the first place or separated that much in the second place," he continued. "Naturally the face of the rim was machined with those strains in there, so now with the strains removed it will be out just as much as the break in each of the spokes. If any effort were made to bring the rim back in line the strains would have to be restored. This, I figure, might be done for the welds could be arranged so the contraction of each weld would cause the metal to draw in again, but even if the job were successful from a welder's standpoint, the pulley would be filled with strains again and would in all probability break when placed in hard service."

"I can see that plain enough," I observed.

"Well, I had to go over all these details with the owners," he went on, in order to make them understand. What I now want to do is make the weld and do away with all the strains. This means that the rim will be a little out of true. It will then be a question of whether it is out enough to warrant taking a cut off it or letting it go. You see the speed of this shaft it's mounted on, isn't very great, so it's being off just a little won't make such a great deal of difference."

"But how about the welding?" I asked.

"Oh yes! I almost forgot about the most important part. As I was telling you, the spoke we have on top now is the first one we'll tackle. The welding itself isn't very difficult. See those carbons my man is fitting to the spoke now? On a horizontal weld like that I always find it easier to handle any cast iron by making sort of a dam beforehand."

"But see! He's fitting carbons on both sides of the same spoke." I broke in. "Won't you make a weld like that from one side only?"

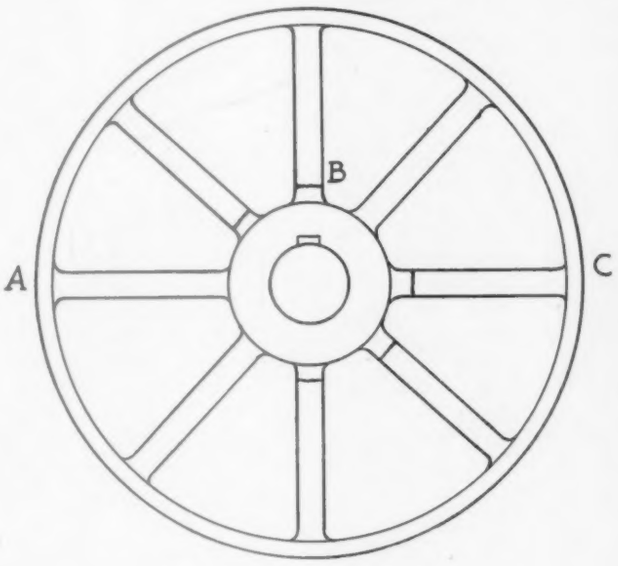
"Ordinarily, yes," he replied, "but not in this instance. I'm going to use two torches on each spoke; one on each side. My reason for making the welds that way is to have as little contraction as possible. When all is said and done, this job is nothing more or less than an expansion and contraction problem. The unbroken spokes were the ones which worried me most, for I could figure out a way to allow for their expansion, but inasmuch as the strains upon them will be set up at an angle of forty-five degrees, I'm going to take a chance. As for the welding, first we'll heat up the rim at two places diametrically opposite, until the broken ends of the spoke are separated enough, then we will—"

"Just a minute, please," I interrupted. "How much is enough and why?"

"Oh, between $\frac{3}{32}$-in. and $\frac{1}{8}$-in. In the usual run of work $\frac{3}{32}$-in. would be the allowance, but here the problem is a different one and I'll probably add another $\frac{3}{32}$-in. and make it $\frac{1}{8}$-in. By doing this I'll be playing safe and throwing any strains that should develop into the rim rather than the spoke. You will probably think I'm not allowing enough to base my allowance on, but with the heavy hub so close to the weld there will be very little expansion on that side."

"But tell me, Pete," I said, "have you any system of figuring such allowances? I'd like to know it if you have."

Pete shook his head. "No I haven't anything that you'd call a system," he said, "but I always remember a little stunt my boss made me do when I was learning the game. He made me get a bar of each of the metals I was learning to weld and cut them off exactly twelve inches long. Then he had me heat each one separately, right in the middle of the bar until it just started to melt. Then the measurement was taken and the amount over twelve inches he told me was the contraction allowance for that kind of metal. He made me prove it by sawing the bar in two, separating the ends the prescribed distance and then making a weld. Sure enough the bar contracted to the twelve inch length when cold or so close to it, you couldn't tell the difference. As he explained at that time, conditions always alter cases and every welder will heat up different areas



Location of Breaks in Spokes.

in making the same kind of a weld, but I've never forgotten that lesson and now I've got to the point where I can tell almost instantly just how much allowance to make for contraction. It stands to reason too, that expansion and contraction in a weld are equal only in opposite directions."

"And, as I was saying before," he continued, "when enough heat has been introduced in the rim to cause the spoke to separate enough, then we'll start in welding from each side and finish it up just as soon as possible. After the first spoke is finished, then the pulley will be turned until the next spoke is in position and the same procedure followed and so on until the job is done. As things stand, it looks as if they are all ready now." He pulled out his watch. "No use starting now; we better eat first." So we hied ourselves to the village and satisfied the inner man.

In the afternoon everything went along fine. I made a bit of a sketch showing the wheel and the spokes where broken. I thought by putting a couple of letters on it that I could describe the job better and you'd understand it. (B) was the first weld. Oil preheating torches were directed against the rim at points (A) & (C) until the ends at (B) were separated enough. Then the flames of these torches were reduced a little, in fact just enough to hold that heat while the weld was being made. One man watched these torches while Pete and his helper did the welding.

Everything went along just fine. They were making much better time than I ever expected. Was rather pleased at the way Pete handled the whole job and say Ed, it sure was a treat to watch him manipulate that torch of his. Between spokes they would have another shot of carbide put in the generators and then they were hard at it again.

One of the lads working in the plant had a camera and in the late afternoon he tried to take a picture of the job, but it was then too dark. Was rather disappointed for I figured I could

send you a print and it would be more clear than my description. However, I slipped the lad a couple of francs and asked him to try again the next day and mail me a print providing the job proved O. K.

At six o'clock the last spoke had been welded and the apparatus was being packed away when "B I N G" something snapped. The welded spokes were all carefully examined but not a sign of a crack. Suddenly someone noticed that it was one of the unwelded spokes that had let go.

"I was a little afraid that would happen," Pete explained to me later. "This rim was getting a little too hot towards the finish."

No time was lost in getting the apparatus set up again and in about an hour this last spoke had been welded. Then I was rather surprised to see Pete give instructions for the wheel to be turned, and have him play his torch on the one remaining unbroken spoke. I knew it wasn't broken, from the way he handled his torch. Later I learned that he wanted to expand the metal a little and let it cool with the rim.

Before starting back home we all went up to the inn and had a young banquet. The return trip was just as wonderful as the one in the morning. The reflection of the moon and stars, dancing on the waves of the Mediterranean was somehow awfully soothing and as we traveled along I told Pete about the deal I made with the camera owner, to send me a picture if the job came out all right. "You'll get the picture; don't worry about that," said Pete. And sure enough Ed, the picture came today. As you will see, the pulley is running, so it's just another case of placing a welding torch in the right man's hands in order to have him do the impossible.

Regards to the bunch.

Yours,

SHEP.

CUTTING OF STEEL IN SCRAP YARDS

(Continued from page 33)

loads rarely consider what the cutting operator will encounter in his work. In this regard, one of the biggest detriments is the placing of unwieldly material in such positions as to be inaccessible without much extra handling—involving either time and men or the use of mechanical equipment.

Often, through carelessness on the part of the laborers and others doing the unloading a great deal of material of considerable tonnage will be buried beneath a mass of light materials so twisted and tangled that it is almost impossible to get at the main body of steel. Or possibly, the steel may be deposited on a thick layer of oily borings or turnings with intermingled rags which begin to smoulder and smoke when ignited, producing a suffocating smoke which drives the operator from the vicinity.

Only recently, the writer personally encountered instances similar to those noted in the preceding paragraphs. In cutting a heavy mass of cast steel that had been left on a thick deposit of borings, the reaction which occurred between the material and the oxygen made conditions insufferable. Furthermore, the smouldering did not cease, but continued to tunnel its way into the large mass so that it could be extinguished only by use of pick and shovel before applying water.

Another case was that in which the material was of such nature that when unloaded it could be cut efficiently only if it had been placed in a certain position. When cut in any other position the costs were very high and created a feeling of animosity on the part of the management to whose attention had not been brought the fact that this was an unusual problem. An actual demonstration soon convinced them that they were directly responsible because of their failure to supervise the work properly, although the operator was somewhat to blame in being negligent about reporting the matter.

The job consisted in cutting a large number of industrial flat cars consisting of a flat reinforced platform supported at each end on a heavy truck construction. The platform was of steel plate reinforced longitudinally by 4-4 inch I Beams. Running transversely near each end were two smaller I-Beams to which were fastened the swivel joint carrying the axles and wheels. A diagrammatic arrangement is shown in the accompanying sketch. Cutting these was a simple matter provided these cars were placed upside down and the cost per ton averaged between $3.25 and $3.50 covering gas and labor charges, and whatever handling was involved in prying a cut section loose.

On the other hand when the cars were left in the normal position, that is, with the trucks on the ground, it became necessary to cut large holes in the platform at the intersection of the cut and each I-Beam in order to sever that member. As the steel was badly pitted and corroded, and the riveting of the reinforcing members had loosened, it was no simple matter to maintain the cut even for the short distance traversed. The operating time became excessive and was attended by much larger gas consumption. The cost under these conditions was almost double the price per ton mentioned previously, and the effect on the operator, who was forced to employ every known trick of his calling, was exhibited on a gradual slowing up, which made him appear to be incompetent.

On the contrary, the operator was known to be unusually skilful in plying his trade and had demonstrated time and time again that he was peculiarly adapted for this kind of work. This may seem somewhat paradoxical, as it is generally assumed that for scrap yard cutting anybody can be adapted in a few hours of instruction. In fact, the idea prevails that the ordinary operator—one who is accustomed to boiler plate work and work of a similar nature—can go into a scrap yard and "burn the place up in no time." This is a fallacy, as the rigorous demands of this especial work are of a nature that generally make the fancy cutter unfitted to assume these duties. If he does, he finds he must unlearn a great many of the fundamentals and readjust himself to an entirely new set of conditions.

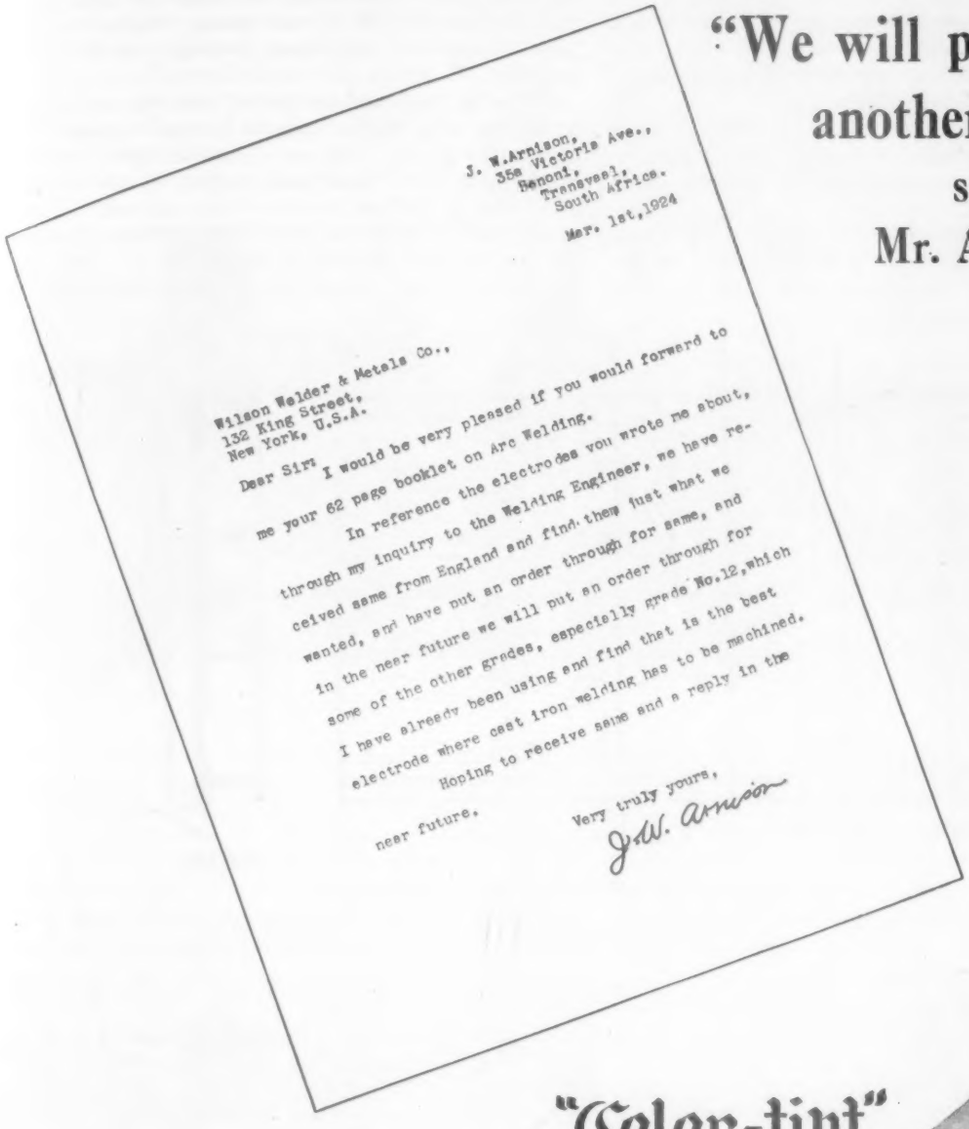
Speed, being a prime factor, any attempt at fine line work is precluded. It is expected and demanded that speed be preferred to the other contingencies and it is of no consequence that the edges be melted, uneven, or oxidized. Adhering oxide is entirely ignored. Perfect penetration is a requisite.

Were all the work of a similar nature, it would become a routine job, and second nature to the cutter to perform it. But no such possibility exists, as the material ranges in thickness, chemical composition, and shape and size to an extraordinary degree and there is rarely a straight run of similar work.

Paints, tar, zinc, corrosion, all play havoc with speed and act as a detriment to perfect manipulation of the torch. Where a large surface suddenly ignites due to the reaction between the oxygen and the chemical constituents of the protective coating, under the influence of the terrific heat, the latter becomes intensified, due to the ignition of a large surface, causing painful discomfort and the danger of being burnt. No matter how well protected the operator may be, he can hardly manage to continue the work until the hazard has been eliminated. It is the safest practice to scrape a path across the surface of any object that appears hazardous or may act as an obstacle by clogging the action of the cutting jet. Scale and rust can be eliminated by scraping or by preliminary heating and striking with a hammer.

In direct contrast to the above is the case where the material is fabricated and consists of several layers of steel, bolted or riveted together and with intermediate layers of rust or paint. It is not easy to raise the lower thicknesses to the proper temperature at which oxidation occurs, and it is only by juggling the torch (wabbling as it is termed) that the kerf can be produced and carried for any length. But "wabbling" means very slow progress, and the result of oscillating the tip of the torch in its forward movement makes the kerf abnormally wide. The combustion of the extra volume of steel consumes an equivalent surplus quantity of oxygen that can only be regarded as wasted gas.

Certain shapes require peculiar methods of attack, not com-



J. W.Arnison,
35a Victoria Ave.,
Benoni,
Transvaal,
South Africa.
Mar. 1st,1924

Wilson Welder & Metals Co.,
132 King Street,
New York, U.S.A.

Dear Sirs

I would be very pleased if you would forward to me your 62 page booklet on Arc Welding.

In reference the electrodes you wrote me about, through my inquiry to the Welding Engineer, we have received same from England and find them just what we wanted, and have put an order through for same, and in the near future we will put an order through for some of the other grades, especially grade No.12,which I have already been using and find that is the best electrode where cast iron welding has to be machined.

Hoping to receive same and a reply in the near future.

Very truly yours,
J.W. Arnison

"We will put through another order," says Mr. Arnison

"Color-tipt"

WELDING WIRE

SPECIAL GRADES FOR WELDING
CAST IRON—BRASS—BRONZE
STEEL—MONEL METAL

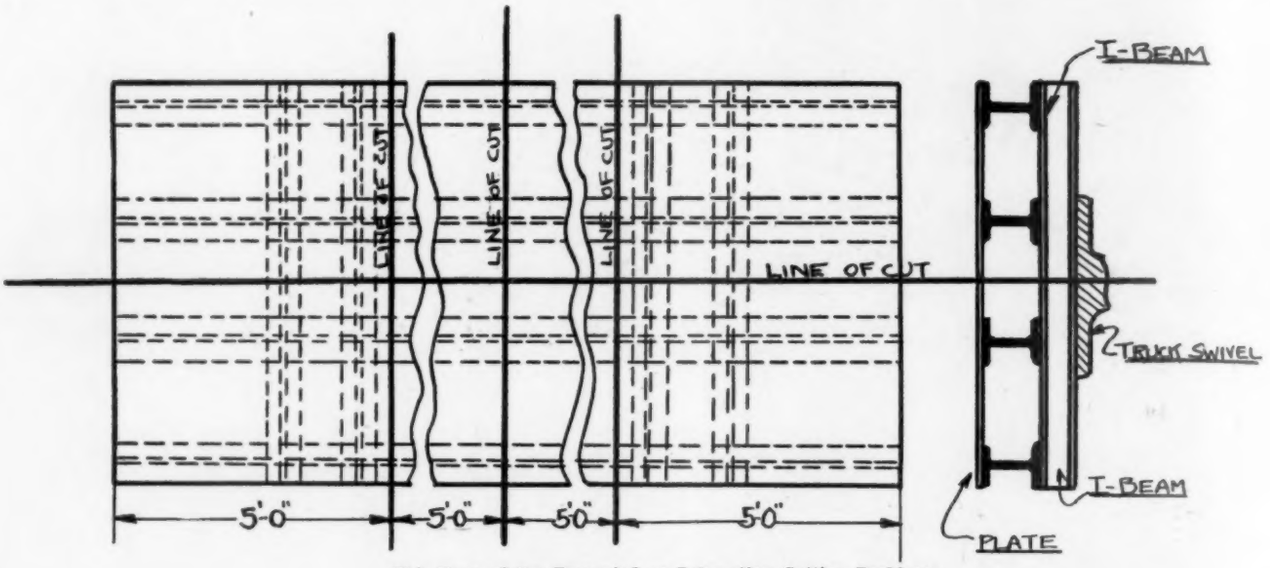
Grade No. 12 Monel Metal Produces a
Machinable Weld in Cast Iron

WILSON WELDER & METALS CO., Inc., New York

monly known to those who rarely encounter them in cutting work, for example, railroad tracks of different capacities.

The upper section of the rail is very heavy as compared to the base and the web. Although cutting can be performed in a number of ways, yet from experience it can be determined that there are certain ways of handling these that will give the maximum production for the least expenditure.

An expert operator can cut rails into 3 foot lengths (about ½ the usual charging box size) for approximately $2.50 or even less, per ton. In order to accomplish this he must understand and be willing to handle his torch in a fashion consistent with the demands of this specific work. That is, for the heavier section he will use the normal oxygen pressure specified for the heavy thickness, opening the cutting valve wide. On the thinner sections he will open the cutting valve to an extent compatible with maximum cutting speed, thus decreasing oxygen waste which results with a wide open valve.



This Type of Car Presented an Interesting Cutting Problem.

Oxygen waste must be guarded against continually. The fact that the other fellow is paying for the gas, combined with lack of supervision and the proper management which checks gas consumption against weight produced, permits operators to employ gas pressures far outside the limits required. Although increased gas pressures produce increased speeds, to some extent yet there is a point where an increase in the gas consumption is in no way warranted, merely inducing excessive oxidation without turning out any more steel. Where this exists it can be assumed that the surplus oxygen is merely passing through the kerf and is being dissipated without performing anything of value.

It is true that some work demands the use of a higher gas pressure than is apparently necessary, but there is generally an underlying reason for it—such as in piercing deep holes, or where the work is in a position where possible lack of penetration may put the operator in an extremely hazardous position if the kerf must be touched up in places.

Some of the larger apparatus manufacturers advocate the use of specially drilled cutting jets, for scrap steel work and it will be found advantageous to use them. The preheating jets are the same as are ordinarily used for cutting the particular thickness but the cutting jet is increased in diameter approximately 20 per cent.

Such changes are not advisable, unless performed under the direction of a representative of the apparatus manufacturer. The design of such tips is generally based upon conclusions formed after long and expensive research and investigation, including costly practical cutting tests and it is made certain that the designs are perfect. And they are, expecting as has been mentioned before, that in some cases a slight change may be of material benefit. But even the slightest change is inadvisable, unless made by one who is entirely conversant with the theory and technicalities upon which tip design is based, otherwise it may be found that the tip has become valueless or may be the cause of mounting expenditures, although appearing to function properly.

Ordinarily, haphazard methods of attacking steel are practiced, no attempt being made to map out a course of action. This may be termed following "the line of least resistance," but it usually works out to be the most costly method. A few moments spent in determining the least number of cuts may mean the diminution of the number of feet of work and is absolutely worth whatever mental effort and time is utilized.

It most certainly would be an impractical performance to sever a heavy section when the same result could be effected by cutting a foot or more of much lighter section. Questions of this sort are daily arising and must be left to the individual operator to decide for himself.

One of the most important questions regarding steel cutting is that which always confronts the dealer,—what does it cost to cut a ton of steel? And this is one that he is generally asking. In most cases it is as simple a question to answer as in the case of "how many chews in a piece of chewing gum?" The dissimilarity of the material, condition of same, position or accessibility, protective coatings, ability of the operator, etc., all play so important a part and are so variable—particularly the material factors—that it is utterly impossible to do anything but hazard a guess and trust to luck to meet it. It is not to be assumed that the figures given in preceding paragraphs can be applied. What passes as a reasonable price in one place may be entirely unsuited in any other scrap yard. It may not even apply tomorrow in the same yard where it was obtained.

On the other hand, where a large tonnage of material is to be converted, all of which is the same type, as for example fabricated columns, ship keels, or railroad tracks, it is possible by an actual cutting test under ordinary working conditions to calculate a fairly accurate cutting cost of the lot. But such figures would hardly apply to a steady run of varying materials found in the yard, where the cutter may be working, now on a casting, then on a light boiler, later on a mass of tangled structural shapes, etc., or where he may be fortunate enough to produce a large tonnage with very little work as against the opposite contingency.

Cost records are of value in any business or industry, and the steel scrap yard is no exception. The usual method is to check tonnage against labor, etc. It is very difficult in this one line of work, however, to make fine analyses of the various jobs and arrive at any definite conclusions. But there is one conclusion that can be drawn, and it is worth while considering. That is,

the average price per ton weight, this price to include the operator's wages, cost of gases (including transportation charges) and the labor involved in the handling of material during actual cutting. An accurate set of records kept for a long interval of time and then averaged properly would give the dealer a fair idea as to what he is accomplishing while records kept on particular lots would give him unit prices that could be applied (with a fair margin of safety) in later estimates when considering large lots of similar nature.

By averaging unit prices as calculated for the different seasons—based on the records obtained over each 3 months for a number of years—a definite idea can be gained regarding the weather effects and such knowledge would certainly be advantageous in mapping out a course of action to be pursued. In certain localities it might be found very profitable, indeed, to perform the cutting during certain months of the year only, and not pursue the work at all during the severe cold weather, whereas, in other localities it would be a satisfactory process the year round.

A—Steel Shaft Guides. B—Carriage. C—Horizontal Piston. D—Vertical Piston.

Equipment Set Up. Ready to Start First Cut.

One-half Way Through. Note Narrow Straight Kerf. Arrow Indicates Device For Controlling Motions of Torch.

One of the Completed Cuts.

This article does not intend to deal with the human problem any further than as has been touched on in connection with the work. The scrap dealer is generally content to leave well enough alone and the operator is usually under no restrictions as to his methods of protection—eye shields, gauntlets, etc. Knowing the hazardous nature of his calling he is usually very careful, so that accident experience in this one line of work has been kept surprisingly low.

Before closing, a word or two should be said regarding cast iron cutting. This is a problem of interest to the dealer in that he often obtains large masses of the material which cannot be shipped without reduction in size. There is no cheaper way of producing the smaller sizes than the present methods employed—the sledge hammer, skull cracker, etc.—and the torch should be left for the specific cases where its use is warranted by the value of the result obtained, regardless of expenditure incurred.

CUTTING-UP WITH OXY-HYDROGEN

TO make a clean, straight cut through a solid steel generator shaft, weighing 40,000 lbs. and 27 in. in diameter, in from 10 to 17 minutes, with a gas consumption of 600 cu. ft. of hydrogen and 2,000 cu. ft. of oxygen per hour, operating on 75 lbs. oxygen pressure and 60 lbs. hydrogen pressure, is such an unusual performance that the methods employed in the operation will be of interest to all users of welding and cutting equipment.

The particular work referred to was done recently by the Purox Company for the Milstein Company of Los Angeles, Cal. The shaft was unloaded from the cars and the cutting done in the Los Angeles yards of the Union Pacific Railway Company to whom the shaft had been sold for the manufacture of drop-forgings, such as locomotive axles, connecting rods and frames, thus necessitating cutting into proper lengths for handling in the forge shop. The work was achieved with a cutting torch, equipped with a straight head and a special hydrogen tip.

The rate of cutting was from 1½ in. to 2 in. per minute and cuts were completed in from 10 to 17 minutes. 12½ ft. each of ⅜ in. oxygen and hydrogen hose were used. Eight cylinders of oxygen were connected to a manifold on the high pressure side and the oxygen delivered to the torch through four regulators, manifolded together. Eight cylinders of hydrogen were also connected to a manifold and the gas delivered to the torch through a single regulator.

Owing to the fact that no power of any description was available at the site where the work was done an extremely ingenious device was rigged up to carry the torch at the required uniform speed up and over the shaft as the cut progressed. The device consisted of a pipe frame work erected over the horizontal shaft and supporting two 1½ in. parallel steel rails laid 6 in. apart horizontally across the shaft and 3 ft. above it. The oxy-hydrogen torch was fastened to a carriage traveling on these rails and propelled by hydraulic pressure from a tee into the oxygen line. The water piston was arranged to pull in either direction, its speed being controlled by a needle valve.

Simultaneous vertical motion was also provided for by a device clamped to the torch and carriage, a second water piston controlling the speed so that the torch traveled around the shaft, cutting the steel, with the tip held constantly at a distance of about ½ in. from the surface.

Altogether, five cuts were made with very narrow kerfs and extremely smooth surfaces, as the accompanying photographs show.

SOME CHEMICAL ASPECTS OF WELDING

(Continued from page 29)

gold the metal itself marks the neutral point, whereas for aluminium it is the oxide, alumnia (Al_2O_3), and for sulphur it is sulphur trioxide (SO_3). This fact, coupled with the 20 per cent of oxygen in the atmosphere, makes it clear that the welder is working under conditions which are, chemically speaking, artificial. Furthermore, the presence of oxygen in the atmosphere tends to nullify the effect of many reducing agents, since it is obviously easier for the reducing agent to combine with the unlimited supply of free oxygen than with oxygen which is bound in combination with a metal.

Natural laws ordain that many oxides shall be extremely stable. Nature always tends to move towards equilibrium or stability, and in view of the enormous quantity of oxygen which exists it is not surprising that so many oxides should possess a high degree of stability.

In illustration of the varying degree of stability of metallic oxides let us consider the extreme cases, viz., gold and sodium. Gold is not affected by the atmosphere whereas sodium is rapidly oxidized at normal temperatures. Gold oxide slowly decomposes into metallic gold at normal temperatures, whereas no amount of heating will convert sodium monoxide (Na_2O) or even sodium peroxide (Na_2O_2) into metallic sodium. The properties of all the other metallic oxides lie between these two extremes; descending in order from the noble to the base metals the temperature at which atmospheric oxidation begins gradually falls and the temperature at which the oxide decomposes rises rapidly. Having thus dealt briefly with the principles underlying the formation of oxides, let us consider the properties of the individual metallic oxides more generally encountered.

Metallic Oxides.—Iron forms three oxides, which, placed in their order of oxidation, are as follows: Ferrous oxide (FeO), ferroso-ferric oxide or magnetic oxide (Fe_3O_4), and ferric oxide (Fe_2O_3). Ferric oxide, which contains 30 per cent of oxygen, is encountered in a hydrated form in the familiar rust. It is also produced when cutting with the oxy-acetylene flame and an excess of oxygen is used. Since the magnetic oxide Fe_3O_4 contains only 27½ per cent oxygen, the formation of Fe_2O_3 in cutting unnecessarily increase the cost on account of the extra oxygen which is required. Magnetic oxide of iron, or scale, is the oxide formed during the welding operation. It is formed on iron when the temperature is raised to incipient redness and is produced very rapidly on the exposed surface of the molten metal. Magnetic oxide melts at a temperature considerably lower than the melting point of iron and most steels, and it has a solubility of 1.1 per cent in the molten iron. When iron or steel is heated, say with a blowpipe, at a certain temperature the heated surface is covered with a layer of oxide. This oxidation may be brought about in several ways, and if the heating be continued the layer of oxide melts whilst the material on which it rests remains in the solid state. If the heating is continued until the metal itself melts, the molten iron or steel can be readily distinguished from the molten oxide because it is less fluid and less brilliant. It is therefore easy to recognize whether the melting is that of the oxide or the metal, yet beginners are apt to overlook the fact that when the metal commences to "sweat" it is only the oxide which has commenced to melt. The melting of welding wire onto surfaces which only show superficially the symptoms of fusion produces very bad adhesion. The oxide is perfectly stable to heat, being neither decomposed into iron or oxidized in the presence of oxygen to Fe_2O_3.

The welding of commercial nickel must be regarded as a difficult proposition. The difficulty in the case of nickel is that the molten metal readily occludes carbon monoxide and other gases, which causes it to swell up and become spongy. A patent has been taken out for the welding of nickel in the presence of carbon or a carbonaceous material. Nickel oxidizes rapidly at high temperatures, forming nickel oxide, an infusible powder. Many welders will be familiar with the formation of this oxide under the name of "burning out the nickel," an alleged process for welding nickel steels without a flux.

Copper forms two oxides—cuprous oxide or copper suboxide (Cu_2O), a bright red powder, and cupric oxide or black copper oxide. These oxides are readily formed by the action of heat on the metal in the presence of air. There has been considerable controversy on the constitution of the oxide formed in welding, and the problem has been further complicated by the high solubility of the oxide in the molten metal, viz., 4.4 per cent. The question is not one of overwhelming importance, but it may be worth mentioning that whereas copper suboxide normally decomposes at 120°C, the large excess of metallic copper present under welding conditions may possibly induce the formation of copper suboxide even at high temperatures, according to the equation:—

$$CuO + Cu = Cu_2O.$$

Copper Oxide and Copper yield Copper Suboxide.

Both oxides are easily converted into the metal by nearly all reducing agents, but their reduction is hindered by the high solubility of the oxide in the molten metal and the delicate nature of the metal renders the choice of the reducing agent a matter of great importance. In welding practice sperial precautions are taken to prevent the formation of copper oxide, at an early stage of the operation, and these will be discussed later.

Aluminium oxidizes in air to alumina (Al_2O_3), with great rapidity at all temperatures. Oxidation being confined to the exposed surface, a film of alumina is formed over the metal, thus preventing further oxidation. This film of alumina is the cause of aluminium vessels being so resistant to many corrosive liquids. Alumina is a white amorphous powder which melts at 2,020°C. as against 657°C. for the metal. It will thus be seen that alumina remains in solid form throughout the welding operation and prevents the union between the base and the deposited metal. The true welding of aluminium is therefore impossible without the use of a suitable flux to remove, or prevent the formation of oxide. In view of the fact that alumina is absolutely stable to heat and that a temperature equal to that of the electric arc is necessary before it is affected by reducing agents, no attempt is made to effect reduction during welding, the main object being to prevent oxide formation as far as possible and to remove completely all the oxide that is formed, and for this purpose a flux of very high efficiency is required.

So far we have dealt only with the pure metals and have made no mention of alloys. It will suffice to say that the oxidation of alloys is approximately equivalent to the sum of the oxidation phenomena of its constituents. One point of importance is that zinc, an ingredient in brasses and bronzes, boils at 918°C. and the oxide volatilizes before it melts.

Non-Metallic Oxides.—The oxidation of the non-metallic elements encountered in welding is somewhat simpler. Oxidation takes place readily, and in most cases the products are gases. The most important non-metallic element is carbon which forms

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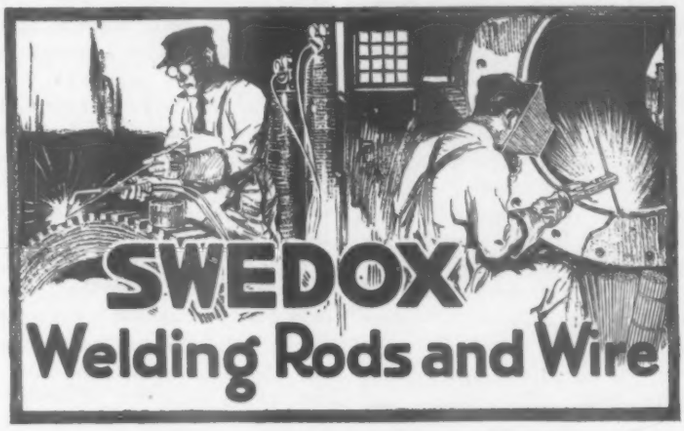

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carbon monoxide (CO) and carbon dioxide (CO_2), both gases. Carbon monoxide possesses powerful reducing properties under certain conditions of temperature, but, unfortunately, welding temperatures are generally beyond the limit, and so carbon monoxide has little or no reducing effect.

Unprotected welds made on iron and steel always show a less of carbon due to oxidation. Diffusion comes into play, tending to equalize the distribution of carbon, and thus the mechanical properties of metal that has been melted are affected.

Sulphur is at all times an undesirable ingredient, and is oxidized to sulphur dioxide (SO_2), a gas. In iron containing a high percentage of sulphur, or more particularly where the sulphur eutectic has segregated, or separated out, the oxidation of sulphur takes place with explosive violence sufficient to scatter the molten metal in all directions.

Phosphorus, another undesirable non-metallic element, is, in most cases, converted into phosphorous trioxide (P_2O_3) and phosphorus pentoxide (P_2O_5). These combine with water vapour to form phosphoric acid, which is corrosive and must be removed.

Silicon occurs in two allotropic forms, a brown or yellow amorphous powder, and a hard black or grey crystal. The amorphos form is readily oxidized to silica (SiO_2). It is the crystalline form, however, which generally occurs in metals, and it is extremely difficult to oxidize this form of silicon with air or oxygen. Silica is an extremely stable substance which cannot be decomposed by the action of heat. It is unattacked by all acids, except hydrofluoric acid, but it is acted upon by alkalies with the formation of silicates.

There is one reaction of the element silicon which is of the utmost importance, and it is as follows:—

$$Si + CO_2 = SiO_2 + C$$

Silicon and Carbon Dioxide yield Silica and Carbon.

This reaction has been extensively used in the oxy-acetylene welding of cast iron. A welding rod of high silicon content is used and carbon dioxide is supplied either by a flux containing carbonates, which decompose on heating to give CO_2, or from the combustion of the acetylene.

Flame Combustion—Electric Arc. At this stage a brief examination of the phenomena accompanying the combustion of acetylene will not be irrelevant, especially as the oxidising and reducing properties of the oxy-acetylene flame have been the subject of much discussion. The complete reaction is represented by the equation:—

$$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O$$

Acetylene and Oxygen yield Carbon Dioxide and Water Vapour.

from which it will be seen that one volume of acetylene requires 2½ volumes of pure oxygen for complete combustion. Most welders will be aware that the practical ratio is 1 volume of acetylene to between 1.1 and 1.7 volumes of oxygen, depending on the pressure of the acetylene and the efficiency of the blowpipe, and a little investigation will reveal the cause of this discrepancy.

In reality the combustion takes place in two distinct stages. Stage I. consists in the breaking down of acetylene and the formation of hydrogen and carbon monoxide as follows:—

$$C_2H_2 + O_2 = H_2 + 2CO.$$

Acetylene and Oxygen yield Hydrogen and Carbon Monoxide.

Stage II. consists in the combustion of the products from Stage I., carbon monoxide being oxidised to carbon dioxide and hydrogen to water vapour, viz.:—

$$CO + O = CO_2.$$
$$H + O = H_2O.$$

The explanation of the discrepancy between the practical and theoretical quantities of oxygen lies in the fact that the bulk of the oxygen in Stage II. is derived from the atmosphere. Thus the properly adjusted oxy-acetylene flame, burning at the nozzle of a well designed blowpipe, automatically obtains sufficient oxygen from the atmosphere to complete combustion, and it therefore follows that if excess of oxygen arrives at the blowpipe nozzle from the cylinder, the excess will impinge directly on the metal causing intense oxidation. If, on the other hand, insufficient oxygen is supplied, there is an excesss of acetylene and carbon is produced probably according to the equation.

$$C_2H_2 + CO = H_2O + 3C$$

Acetylene and Carbon Monoxide yield Water Vapour and Carbon.

As all the components in the combustion of acetylene are gases moving at high speed, it is obviously unreasonable to expect Stages I. and II. to be sharply divided. The combustion may, therefore, be said to take place in three zones, as illustrated in Fig. 1.

Zone I. is the luminous zone and contains all the components of Stage I., viz., acetylene, oxygen, hydrogen, and carbon monoxide, the reaction not being complete at the end of Zone I. Zone II. is completely non-luminous and in it Stage I. is completed and Stage II. also begins. The atmospheric oxygen comes into play at the beginning of Zone III. where the reaction is completed. It is Zone II. that is of most interest to the welder, as all welding operations are carried out at various positions in this zone, the nature of the metal, its melting point, and the dimensions being important factors in fixing the best position.

With regard to the temperature of the oxy-acetylene flame, the determination of the temperature is a matter of great difficulty, no authorities have yet been able to agree about it. The values given for the highest temperature vary from 2,000°C to 4,000°C. and these two values can be taken as extreme values not obtainable in ordinary practice. The importance of using gases of the highest degree of purity to avoid the reduction of temperature and loss of heat has been demonstrated by Mr. C. Bingham in a paper on "Impurities in Acetylene." It is impossible to fix temperatures without having definite conditions but with good apparatus and pure gases well balanced, the temperature existing in the flame will attain 3,000°C. but does not exceed 3,500°C. The diagram of Fig. 2 will serve as an approximate indication of the temperature at various points along the axis of the flame, from which it will be seen that the temperatures in Zones II. lie between 2,000°C. and 3,000°C.

The composition of the gases in Zone II. is as follows: Two parts carbon monoxide and one part hydrogen with very small quantities of acetylene, oxygen, carbon dioxide and water vapour The following analysis is purely hypothetical

Carbon monoxide	60%
Hydrogen	30%
Carbon dioxide	4%
Water vapour	4%
Acetylene	1%
Oxygen	1%

It would appear at first sight that a gaseous mixture of such composition should possess powerful reducing properties, but two must be considered. Firstly, the reducing properties are completely destroyed in Zone III., and secondly, at the temperature 2,000°C.—3,000°C. of Zone II., the stability of all common oxides becomes so great as to render them unreduceable by carbon monoxide or hydrogen. This fact destroys the fallacy, which is found even in recent books on welding, that the oxy-acetylene flame is a reducing flame and consequently eliminates the necessity for fluxes. In the opinion of the writer, the only active constituent in Zone II. is the very small quantity of oxygen, which gives the zone a feeble oxidizing action. Whether this opinion be right or wrong, it is a very safe assumption for the welder to make.

In the electric arc the conditions are greatly simplified, and it is safe to consider the arc as a neutral source of heat provided it is properly protected. If oxygen is allowed to pass directly through the arc, however, it assumes intensely oxidizing properties, as is amply illustrated by the modern process for the manufacture of nitric acid, in which a mixture of oxygen and nitrogen is caused to pass through an electric arc, and nitrogen which is usually very difficult to oxidise, is converted into nitric oxide. It may be of general interest to mention that the temperature of the arc is about 3,500°C.

(To be Continued)

News of the Welding Trade

A four-page illustrated circular featuring an improved type of high pressure cylinder valve has recently been issued by the Harris Calorific Co., of Cleveland, Ohio.

E. L. Mills, Sales Manager of The Bastian Blessing Co., Chicago, has just returned from a long business trip to the Southwest.

"Welding World History" is the title of a circular recently issued by the Purox Company, Denver, illustrating the welding operations performed on the United States airships which started their around-the-world flight on March 17.

The Rules for Safe Handling of Cylinders, recently prepared by the Gas Products Association, Chicago, have been printed on heavy paper in suitable form for posting on bulletin boards of factories and welding shops, and will be furnished to those interested, upon request.

The firm of Gustafson & Swanson has taken over the welding shop formerly operated by Ebright & Luthy, at 1121 N. Ashland St., Chicago. George Gustafson, the senior partner, is one of the well known welders around Chicago, and is well fitted by his experience to make a success of the new shop.

"The Application of Electric and Acetylene Welding" is the subject of a paper to be read before the Cleveland Section of the American Welding Society, on April 15, by E. A. Bissell, of the Westinghouse Electric & Mfg. Co., Pittsburg.

At a recent meeting of the American Society of Heating and Ventilating Engineers held at Buffalo, Mr. H. H. Melville, of the Air Reduction Sales Company, New York, was one of the speakers.

Philip G. Wesley has been elected Secretary and General Manager of the Buckeye Oxygen Company, Canton, Ohio.

Bulletin No. 101 of the Purox Company, Denver, describes and illustrates containers for carrying liquefied gases. The containers are specially designed for the shipment of liquid oxygen.

The Central Welding Co., Lansing, Michigan, is planning to build a larger plant and install additional equipment in a new location at Turner and Howard Streets.

A new building, part of which is to be used for a welding shop, is being constructed by the Salt City Welding and Machine Shop, Hutchinson, Kansas.

Circular No. 177-B of the Imperial Brass Manufacturing Company, Chicago, describes and illustrates Imperial welding and cutting equipment and gives a diagram of the Imperial Type A Acetylene Generator.

Announcement is made by the Oxweld Acetylene Company of the transfer of Mr. W. H. Roll, from the Eastern Department to the Central Department at Chicago, where he will be assistant to Mr. C. E. Ziesel. Mr. Roll's place, as assistant to Mr. L. D. Burnett in the Eastern Department, has been taken by Mr. Zachary T. Davis, Jr., formerly of the Central Department, and later of the Publicity Department. Thus Mr. Davis takes up again his sales duties after a most extensive and valuable experience in publicity work.

The Cave Welding Co., welders and manufacturer of boilers and gas and oil tanks, Springfield, Mass., is moving from its old quarters in Taylor St. to a new site at 453 Worthington St., which will increase its space by about 60 per cent.

WELDING EXHIBITS AT RAILWAY SHOW

At the sixteenth annual exhibition of the National Railway Appliances Association, held at the Coliseum, Chicago, March 10 to 13, the following firms were represented: Metal and Thermit Corporation, New York, thermit rail welding; Air Reduction Sales Company, New York, welding and cutting demonstrations and equipment; Carbic Manufacturing Company, Duluth, Carbic generators, welding and cutting apparatus; Torchweld Equipment Company, Chicago, welding and cutting apparatus; Page Steel & Wire Co., Bridgeport, Conn., welding wire; Oxweld Railroad Service Co., New York, railroad welding; General Electric Co., Schenectady, N. Y., demonstrations of automatic arc welding.

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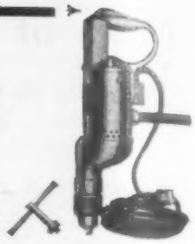

CURRENT WELDING LITERATURE

SOME CHEMICAL ASPECTS OF WELDING, by J. R. Booer—A discussion of a paper recently read before The Institution of Welding Engineers with a special intention to the use of fluxes and the effects of oxidation.—Acetylene and Welding Journal, London, March.

FLUXES AND THEIR FUNCTIONS IN ELECTRIC ARC WELDING, by Major James Caldwell—Classification of electrodes with regard to covering. In addition to the flux composition, other requirements are that it must not melt too easily or have too high a melting point. The covering should fuse level with the rim of the crates of the rod. A special covering for electrodes to be used in overhead welding is recommended.—Acetylene and Welding Journal, London, March.

METALAYER SCHOOP PROCESS—Booklet issued by Metals Coating Company of America, Philadelphia, Penna., describing a process for coating metals. The principle involved consists in feeding a metal wire into an oxy-acetylene flame, then blowing it violently by an air blast against the surface to be coated.

OXY-ACETYLENE BRAZED JOINTS FOR CAST IRON GAS MAINS, by A. F. Bridge and M. R. Thompson—Cast iron is recommended on account of its longer life. The difficulty of making satisfactory joints has lead to the adoption of a joint which consists of a thick bronze collar applied to the ends of the cast pipe sections. A variety of tests indicate that the brazed joint will give good satisfaction in service. The development of improved methods of manufacturing cast iron pipe promises to encourage further application for this type of joint.—Acetylene Journal, April.

SOME CHEMICAL ASPECTS OF WELDING, by J. R. Booer—A technical discussion of the chemical principles involved in oxy-acetylene and electric arc welding. Various forms of oxides and how they are produced—An investigation of the characteristics of the oxy-acetylene flame—Methods of preventing oxidation—Reducing Agents—Acetylene Journal, April.

OXY-ACETYLENE WELDING OF DURIRON, by B. R. Young—Duriron is an acid-resisting iron which has a slightly higher melting temperature than cast iron and flows much more freely. The principal difficulty in welding it is to prevent cracking. Low cooling after welding and reheating is recommended. While welding, care must be taken to keep all parts of the casting adjacent to the weld as nearly the same temperature as possible. A small amount of cast iron flux should be used and the puddle constantly stirred.—Acetylene Journal, April.

SAFETY IN GAS WELDING AND CUTTING, by H. S. Smith—Recommendations for the storage of calcium carbide and cylinders of compressed oxygen and compressed acetylene—Suggestions for the proper storage of acetylene generators—General rules for the operation and recharging of acetylene generators—Suggested tests for gauges, hose lines, etc.—Acetylene Journal, April.

O¼Y-ACETYLENE TIPS—Monthly publication of Linde Air Products Company. The April issue contains a story of service rendered by oxy-acetylene engineers in a steel mill; a story of the use of a cutting torch as a production tool in making rope machinery; a description and illustrations of jigs used in making manifolds, exhaust tubes and trunks; the use of the welding torch in fabricating working models from sheet metal; The use of the torch as a production tool in making sand sifters; The welding of engine pans from steel stampings and forgings; A variety of uses for the oxy-acetylene process in water works; How the torch is used to reduce production cost and to save valuable castings from the scrap heap.

SCRAPPING SEEL CARS BY ELECTRIC ARC PROCESS, by A. M. Candy—Facilities and methods which are applicable where a large number of cars are to be handled—Time required to cut up a car depends on the number of feet of cutting. It is advisable to provide all the facilities possible to speed up the work and make it easy for the operator.—Railway Mechanical Engineer, April.

FABRICATING HEAVY PLATE BY OXY-ACETYLENE WELDING—A description of the welding operations in connection with the construction of two 1,000 barrel oil storage tanks, a 125 foot rotary kiln and 50,000 cubic foot gas holder.—Boiler Maker, March.

ADEQUATE TRAINING NEEDED FOR WELDING OPERATORS, by C. E. Lester—Successful flue welding can be accomplished by using good material and equipment, and by carefully preparing the parts—How to make tight flue welds—Causes of overheating—The amount of metal in the weld—Failures are the result of faulty applications.—Boiler Maker, March.

SAFETY IN ELECTRIC WELDING AND CUTTING, by D. H. Devoe—Methods of protecting the eyes and bodies of arc welding operators—Suggestions for safe-guarding the apparatus.—Boiler Maker, March.

STEEL WELDING—A description of proper methods of adjusting the flame and manipulating it for the welding of steel, with particular reference to thin sheets—How to avoid hard spots and how to avoid burning.—The Oxygen Digest.

WELDING STANDARDIZATION IN LOCOMOTIVE SHOPS, by James S. Heaton—Methods used in the preparation and execution of locomotive welds—Frame welds and cylinder welds—Stoker repair work—Superheater units—Broken wheel spokes and tires—Care of equipment—Railway Mechanical Engineer, April.

THE JOB WELDING SHOP SHOULD BE MORE THAN A REPAIR SHOP, by S. Wade—How the business can be made to grow by soliciting some production work for the shop.—Journal of the A. W. S., February.

THE JOB WELDING SHOP, by A. F. Koegh—Qualifications of Owner, Manager, or Foreman, Organization, Capital, Location, Handling customers, Getting business, Advertising, Handling outside jobs, Guaranteeing jobs, Supplies, Dealing with salesmen, Cost cutting, What a job is worth, Hazards, Credits, Extra Help.—Journal of the A. W. S., February.

TRAINING COURSE FOR ELECTRIC ARC WELDERS—Report of the committee on Training Operators of the American Bureau of Welding—Qualifications for electric welders—Some of the fundamentals in arc welding and analysis and progress of the welding students illustrated by type jobs.—Journal of the A. W. S., February.

PROGRESS REPORT No. 2 OF COMMITTEE ON WELDED RAIL JOINTS—A summary of tests to date—Procedure and comments on Tensile tests—Bending tests—Drop tests and Conductivity tests—Additional information furnished by makers of various types of joints.—Journal of the A. W. S., February.

SMITHOGRAMS—Monthly publication of Smith's Inventions, Inc. The March issue contains an article on the subject of Sheet Metal Welding which illustrates some useful jigs for sheet metal work.

COMBINED RIVETING AND WELDING, by H. E. Rossell—There are some cases in shop construction where the combined riveted and welded joint may be used to good advantage. In one particular case it is pointed out that this combination gave plenty of strength and also resulted in a great saving in the cost of construction.—Marine Engineering, April.

STUDY OF THE CUTTING TORCH, by M. Piette—The causes of unsatisfactory results on oxy-acetylene cutting are ignorance of the exact nature of oxy-acetylene cutting, ignorance of the construction and operation of the torch, and the use of tips not suited to the work and of pressures which are too high. Difficulty in determining and controlling the pressure, and the rate of progress and difficulties presented by peculiarities of construction of some types of torches.—Revue De La Soudure Autogene, February.

MAINTENANCE OF WAY RECLAMATION BY THE OXY-ACETYLENE PROCESS—One of a series of booklets issued by the Air Reduction Sales Company. This has particular reference to Frog Welding, Crossing frog welding, Building up rail joints, Switch point welding, and Rail Bonding. Methods of making repairs and the savings obtained by using the welding process are explained in detail.

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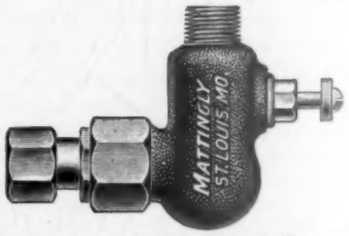

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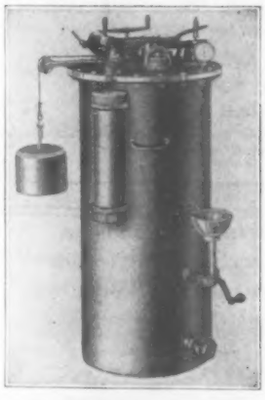

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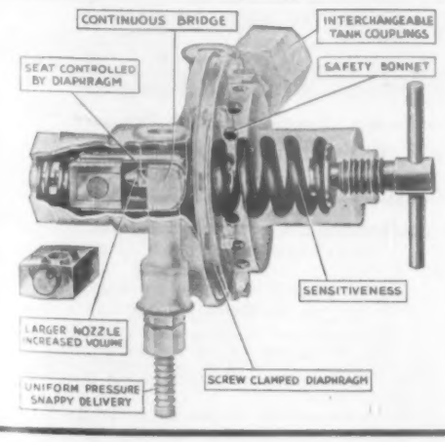

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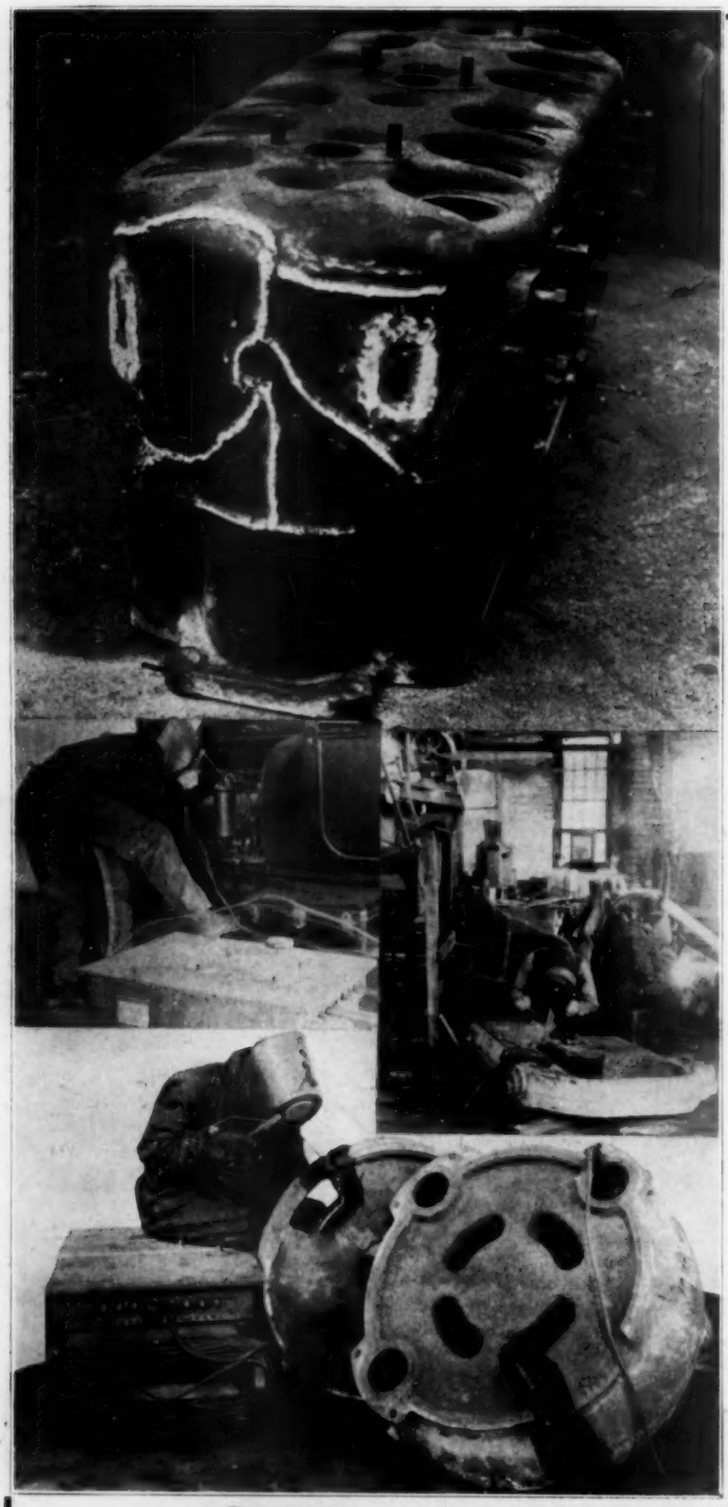

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